Supplement to

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Proceedings of the N.C.A. Technical Sessions at the 40th Annual Convention

In this Supplement to the INFORMATION LETTER of January 31 (Convention Issue) are assembled reproductions of the 12 papers presented at the three Canning Problems Conferences held during the week of the 1947 Convention of the National Canners Association at Atlantic City, N. J. The papers are grouped and published in the same general sequence in which they were presented at the conferences, and all of them are reproduced in full. In addition to the papers presented at the Canning Problems Conferences, this Supplement contains two papers presented at the conference on January 20, sponsored by the Corn Canners Service Bureau, which are on subjects similar to those covered in the Canning Problems Conferences. Copies of this Supplement are being mailed to all canner-members. Additional copies will be available on request, and it is also planned to make available separate reprints of the individual papers for those who prefer them in that form.

LEGAL ASPECTS OF TECHNICAL PREPARATION FOR HEARINGS ON FOOD AND DRUG STANDARDS

By H. Thomas Austern, Counsel, National Canners Association

Even the formidable title selected for this paper is hardly adequate. Were it feasible, I should have preferred the title also to have stressed canner participation. For more is needed than merely to marry the praiseworthy caution and honest uncertainties of the scientist to the insistent demand of the lawyer for complete demonstration on every point. This joining of technician and lawyer in intellectual wedlock, often with reluctance on the part of both, can never take place unless the canners concerned furnish an adequate dowry of necessary information.

The extent of what may be needed is measured by the probable program of the Food and Drug Administration with respect to standard making. Agreement exists among most men in both industry and Government that the Federal Food, Drug and Cosmetic Act cannot be efficiently and effectively enforced in the absence of adequate, workable standards of identity. And forward-looking canners appreciate that the primary force of a minimum standard of quality is to protect the reputation and integrity of canned foods even though it equally affords protection to the consumer. For these reasons it is believed that the program of standard making will go forward at a probably accelerated pace, limited only by whatever budget inadequacies may control the extent of administrative effort.

As you know, many important canned foods are not yet covered by minimum standards of quality. In the vegetable group these include asparagus, green and wax beans—recently the subject of a hearing—lima beans, beets, corn, carrots, pumpkin and squash, spinach and potatoes. Among fruits there are neither standards of identity nor minimum standards of quality for apples, apple juice, apple sauce, cranberry sauce, figs, grapefruit juice, grapefruit segments, orange juice, pineapple, pineapple juice, plums, and prunes. Neither type of standard has been promulgated for any fishery product, although standards for the fill of container have been adopted for canned oysters and canned shrimp. And while it is not too clear to what extent such products as canned soups or canned baby foods are susceptible to standardization, it is not entirely beyond the bounds of probability that these foods may at some future time be considered in the standardization program.

Legal Background

Since the legal background is first offered this afternoon, I may be forgiven for suggesting that a lawyer looks first to the controlling statute. This is the Federal Food Drug and Cosmetic Act of 1938. Its provisions for the development of standards of identity and minimum standards of quality are considered legally unique. In the first place, there are few peacetime Congressional enactments which give to administrative officials as wide a scope of authority to issue regulations having the force of law as do the provisions of Sections 401 and 701 of the Food and Drug Act.

In the second place, in few statutes are the standards, or the legal guides to govern the action of administrative officials, as vaguely stated; and in no other law is the peculiar process of legislating by litigation established in exactly the way in which it is set up in the Food and Drug Act. Lastly, in the ten years since its passage the prevailing legal theories according to which both the Government and the food industry have sought to carry

on have shifted in many important ways.

However interesting all of this may be to lawyers, it has important, practical dollar-and-cents importance to food processors. For this reason the National Canners Association through its laboratory staff and its general counsel has endeavored during the past year to carry on an educational program. This program was designed to accomplish several ends: *First*, to bring home to those canners who would be affected by anticipated new standards, some of the significant things about the proceeding; *second*, to coordinate, insofar as humanly possible, the efforts of all those who were interested in the product being standardized, and, *third*, to crystallize well in advance precisely what the National Canners Association, and particularly its scientific staff and general counsel, could most effectively do to assist the particular group of canners.

Need for Program Demonstrated

The necessity for some such program was abundantly shown by the recent hearings on the proposed standards for green and wax beans. And without trenching upon Mr. Smith's discussion which is to follow, I might say that it is my hope that the expected hearings later this year on canned corn will demonstrate the value of the program.

At the outset, a few fundamentals must be remembered. The standards which emerge from these proceedings are embodied in regulations which have the force of law. They are in no sense voluntary. Compliance with them and use of the labeling which they prescribe is mandatory upon every canner packing the standardized product. Confusion on this point at this late date should not exist. Even more important is the *rigidity* inherent in the federal statute. Once a standard of identity is promulgated, a product which is either labeled under the name of the particular food or which resembles it, cannot be packed unless it is in full compliance. As the Act puts it, the standard applies to any product which "purports to be or which is represented as" the standardized article. This means that no essential ingredient can be left out, and what is probably more important, no additional ingredient can be added. The only recourse for one with a new development is to ask for an amendment of the regulation. This, many have found, is a cumbersome and costly process.

Whether this rigidity is good or bad is a separate question. Proposals have been made to amend the statute to permit experimental packs for the development of new products, and some state laws permit this for intrastate commerce. But we are dealing with the law as it stands and not as it should be. Because of this, I should like to plead as earnestly as I can for a better realization of both the consumer interest in these proceedings and the seriousness and permanence of the economic impact of the standards which will emerge from these hearings. If a canner were confronted with a law suit in which there might be entered a judgment for a substantial part of his net worth, I am confident that he would not take the matter casually. Neither should he so take these standard hearings. To pursue this analogy, if the law suit might involve not only the payment of a substantial sum of money at the present time but might also result in a charge upon everything he might do or earn for years to come, it cannot be questioned that any man confronted with this situation would be gravely concerned, would regard it as one of his major problems, and would start doing everything in his power to get ready for the day of trial.

Yet in the five years preceding the war, when the standard making proceedings for canned foods were extremely active, it is extraordinary how desultory was the attention given, how fragmentary was the effort, and how seemingly detached was the attitude of many canners.

Perhaps the simplest way to conclude this point would be to say that each canner must realize that when a hearing is held on a proposed standard covering any product he packs, he will be controlled for probably a decade by what is done at that hearing. What he may pack, how he may pack it, how he may label and how many different labels a given pack will require, what part of his total pack from year to year will have to take the crepe label, in large measure the cost of important parts of his operations, and the ultimate return he may get from his season's efforts—all of these will be dependent upon what administrative officials will formally decide in the proceeding.

Need for Preparation

Necessarily, this approach to the hearing problem leads to a realization of the need for intensive preparation. The first question is that of time. The statute requires only that the Administration give 30 days' notice. In the case of seasonal canned foods, this manifestly is not enough. The informal practice, if it is followed, usually affords additional time. Indeed, informal announcement of the probability of the corn hearings was made in the Spring of 1946 and prior to the 1946 pack. Yet there is serious question whether for a product packed in various styles from many varieties of a fruit or vegetable grown in different areas, even one year's notice is sufficient. This lesson emerged from the bean hearing where, by any fair appraisal, neither the Government nor the industry was adequately prepared to evaluate the proposal or to suggest corrections for what was demonstrably wrong.

A related problem is found in the fact that the formal hearings, at least on important products packed in large volume, are held on a proposed standard formulated by the Government. Here again, experience at the bean hearing was illuminating in that many factors proposed by the Government for the quality standard were thought by industry representatives to belong in the identity standard. Perhaps the solution to this may be found in preliminary, informal meetings for the discussion of these problems. There exists in the Food and Drug Administration a Food Standards Committee which can hold such hearings. If it proves feasible to have free discussion with a candid give and take of ideas, without rhetoric or dissention, and necessarily without either Government officials or industry technicians being in any way bound legally by what they say, it may turn out that this method will solve many problems.

Unfortunately, the process of legislating by litigation gives to these proceedings an adversary character. The practical result is that the industry sometimes appears to be ranged in opposition to the Government. This need not be true but the statutory framework does make it highly desirable that differences of opinion among canners be resolved by evaluation of the technical data *in advance of the hearing*.

Too often in the past, in these standard hearings, canners from various sections have failed to reach agreement among themselves as to what recommendations to make to the Administrator. It has been suggested that this may have been due to the zeal or perhaps the persuasion of lawyers for the various groups. Nevertheless, it is a fact that frequently conflicting testimony has been put in. Whenever this occurs you may take it as a legal absolute that the Administrator is free to accept the testimony of his own officials or of any particular industry group and can do so with almost complete freedom on this state of the record.

The statute requires that there be "substantial evidence of record." This means to a lawyer that there be evidence—and not protests and argument. Evidence means cold facts. Necessarily, in this field, there must be interpretation of the facts. This is either the job of the qualified scientific expert or trade expert or, so far as argument from facts is concerned, for the trained lawyer. Too many canners seem to think that an appearance at the hearing or the presentation of evidence means simply that they come and voice their protests. This has been the chief weakness in much that has been done up to date. Let me assure you that a table of

results of analysis covering a comprehensive segment of the pack is, *as evidence*, worth twenty witnesses voicing their opinion that a proposal is unreasonable. One flow-chart of a cannery, or picture of cannery machinery, is better evidence of why a proposed requirement cannot be met by good manufacturing practices than repeated vague assertions by any number of canners.

Another aspect of this same problem is that nothing is more confusing than different testimony about a great deal of wholly *different* data. In dealing with food products for enforcement purposes, Congress itself recognized that having identical samples is a key requirement. When goods are seized, both the statute and the regulations permit the man whose goods are seized to secure a portion of the official sample so that he may examine and testify about the *same lot* of goods as will the Government.

These same principles should apply in the presentation of information for the far more sweeping *and certainly more important* business of formulating standards to control an industry for many years in the future. It is only a matter of common sense that if a canner gives samples to a government official for use in preparation for a standard hearing that he retain a generous sample from each of the lots given to the Government for use by himself and by those who act in his interest at the same hearing. It is only common sense that whenever he offers information, either general or specific, about his pack for these purposes, that he make a memorandum of what he has said, and send a copy of it to the Association's Laboratories for their illumination. Likewise, as Howard Smith has pointed out, it serves no useful purpose for one canner to give to a government inspector samples bordering on a standard-substandard line, and for another canner to give samples reflecting a cross-section of his entire pack. The result is only confusion and out of this confusion arises the possibility of administrative action on inadequate data and the practical loss of the procedural safeguards afforded by the law.

Presentation of Testimony

I hope I may also be forgiven for saying a word about amateur lawyers. In the profession there is a rather arrogant proverb to the effect that any man who attempts to act as his own attorney usually has a fool for a client. Whether this is true or not, I can assure you that nothing is more frustrating than carefully to make a record on a given point in a food standard hearing only to have some canner whom you have been trying to help ask a lot of questions and completely fudge the record—which up to that point may have been reasonably clear. I am not suggesting that the practice of free questioning at these hearings be abandoned. I am suggesting that if adequate time is afforded for preparation with counsel, it might be regarded as desirable to let the fellow who is presumably trained and experienced carry the ball on cross-examination.

Related to this plea is a professional trade secret. It is a commonplace in law practice that any type of case is usually won or lost in the preparation and not in the trial. The plain fact is that neither important litigation nor important standard-making can be played "by ear." This means that the data to be discussed must be carefully studied in advance by people competent to evaluate their probative use and perhaps to find their weaknesses and strength. No competent lawyer will present to a hearing officer data which he himself thinks are vulnerable. Moreover, he will not ask one qualified witness to sponsor someone else's work, even if he had so little respect for rules of evidence as to attempt it.

This adds up, I think, to the conclusion that if a helpful job is to be done by any group of canners at a standard hearing, a good job must be done on the assembly, examination and coordination of the basic data. A practical illustration of this problem will develop, I am sure, from Mr. Smith's discussion of what has been done thus far for the corn hearing.

As a general matter, however, I should like to offer from the point of view of the lawyer, some suggestions which may constitute the ideal but which at the least may be deemed worth while objectives:

Insofar as possible the industry should have samples and information paralleling that known to have been obtained by the Government.

The industry data should all be examined by a common method, by equally competent people, and tabulated and presented in uniform fashion.

A sharp line of demarcation should be drawn between the assembly of data and their interpretation, and particularly argument about them.

Scientific witnesses should be permitted to state their opinion about the methods used. Scientific witnesses should *not*, however, be drawn into discussions about the commercial effects of any proposals. Questions of trade practice—questions of what can or cannot be done as a matter of practical cannery operation—should be dealt with by practical cannery witnesses, and this job should not be mixed up with the work of the scientific witnesses.

There should, so far as possible, be no basis for controversy as to scientific results. Necessarily, there may be differences of opinion as to practical operating questions, and differences of opinion as to the commercial and economic impact of a particular requirement on different areas. But if a given testing method—in the hands of a competent scientist—yields a given result, this should not be a matter for argument among canners.

Trade Testimony as Measuring Rod

The trade testimony should be developed as a measuring rod. Industry evaluation of samples—in terms of commercial grading, in terms of growing conditions, in terms of processing techniques—should be the yardstick for interpretation of the scientific results. For example, if we know that particular samples—according to industry and trade evaluation—are deemed clearly above the standard line, the data offered by scientific witnesses and the data offered by trade witnesses can be correlated. We can say that a given AIS level, for example, is the point at which the trade evaluation would draw the line. If the trade witnesses agree that a given group of samples is clearly substandard, these samples can be identified to tie into a particular level in the scientific data. The only place where differences of opinion may exist should be in the various commercial evaluations and not in the scientific tables against which they will be compared.

Lastly, it is a great deal better if the entire presentation—if what everybody is going to say—is completely coordinated. Practically, this can be done only by centralizing the responsibility for the preparation and the conduct of the hearing.

My remaining observations consist of a brief primer on the law. I have already mentioned what constitutes evidence.

. It might be well also to indicate how basically confusing is the problem of deciding what is a "factor of identity" and what is a "factor of quality." To put this another way, how can it be determined what legally belongs in a standard of identity and what belongs in a standard of quality? If you are not too clear about this, you may take comfort in the fact that nobody else, lawyer or layman, government official or processor, has ever been entirely clear. Fruit canners commercially regard syrup density as a matter of quality. The Administrator made it—and it is now the law of the land—a factor of identity. Offhand, one might say that whether a can of peas was or was not artificially colored was a matter of identity. The canned pea standards make it a matter of quality. Up to the time of the bean hearing, I thought that uniformity of size of cut pieces in canned green beans was a question of quality. Today I am not quite clear, after the bean hearing, whether it is identity or quality or perhaps both. In the case of corn, as you will learn, the question of consistency of cream style corn may be a matter of either identity or quality.

Perhaps the suggested preliminary

meetings with the Food Standards Committee, if they can be arranged, will serve to clear up some of these troublesome questions of factors of identity versus factors of quality. To a greater or lesser degree, they will arise to trouble you in future hearings, particularly as further minimum standards of quality are developed.

The important thing to remember is that these issues are not legal abstractions. Every change in identity, that is, every new identity factor, may mean an additional set of labels and additional costs in segregation of pack and ultimately increased cost to the consumer. Every quality factor may mean at some level the difference between a regular and a crêpe label. The balancing of these interests is inherently difficult.

Just to make the matter somewhat more confusing—both to the lawyer and the canner—the Government some years ago introduced the concept of an "optional form of ingredient." As near as I can tell this may or may not be objectionable, depending upon the form it takes. It may simply mean, as in the canned pea standards, that several standards of identity are rolled into one. On the other hand, it may mean, as in the case of tomato puree, that the Government is in reality controlling methods of manufacture and not any distinguishable identity differences in the finished product. Use of starch in canned corn may raise the same questions. I mention these points because they illustrate the necessity for a lot of hard thinking, not only the day or so before a hearing, but well in advance of it.

Issue of "Common or Usual Name"

Another question of considerable legal importance—and again legal confusion—is the issue of the "common or usual name." Many of you may remember the proposal to call all golden bantam corn "yellow" corn. Naively, I always thought the common or usual name of a canned product was the name under which it had gone. This would mean that if you proved how the product had been labled in the past, you proved its common or usual name. Yet in the bean standard proceeding the proposal tentatively advanced at the hearing but later incorporated in the proposed standard of identity was to use the term "Jumble Pack" for whole green and wax beans; and, as an alternative, to employ a wholly coined label designation of *"Packed Without Arrangement."* Unfortunately, and in many instances because some products are labeled very differently in different parts of the country, these questions of nomenclature are not easy. I do not think this type of difficulty can be solved by the creation of inapt and unfamiliar terms likely to cause confusion among consumers, and this is particularly true when a fanciful name thought up by some witness carries a connotation of undesirability. Once again, some intelligent and hard thinking is needed.

Legally, every standard must be "reasonable." This requires evidence —and again I mean evidence, and not protest and argument—as to *why* a particular requirement would be unreasonable. This means evidence as to operating difficulties, increased costs, effects upon growers, etc.

Varietal Differences

Another statutory protection which you should keep in mind is the requirement that in prescribing any standard of quality "consideration shall be given and due allowance made for the differing characteristics of the several varieties of such fruit or vegetable." Thus where a varietal difference may mean that a requirement would be reasonable for one canning section but onerous and unreasonable for another, the job is to present precise evidence as to why the growing conditions and manufacturing procedures are *different*. This type of evidence is very important legally, and has not been as fully stressed as it perhaps could have been. I might add that in the bean hearing it may turn out to be controlling with respect to certain proposals.

Basically, the ultimate legally relevant issue is what will promote "honesty and fair dealing in the interest of consumers." I don't know what this means, and after ten years I know less than I thought I knew when the law was passed. In the first place, I don't know how to prove what is in the interest of consumers. The Government appears to dismiss lightly, evidence as to what the canner thinks on this point. It does not regard as too important the fact that a particular product has sold, or that it has been accepted by the consumer. On past experience the Administrator seems to regard highly the *opinion* testimony—usually not backed by either broad experience or any specific survey of a particular product—of professional consumer witnesses or representatives of consumer groups. And I do not see how the testimony of a government official, where he has made no consumer survey, is any better evidence than that of a canner. Yet Food and Drug officials in hearings usually testify as to what is in the interest of the consumer.

It seems to me that we must lick this fundamental problem if we are to achieve the degree of participation in formulating these standards which Congress contemplated the industry and public at large were to have. A recent article by a lawyer formerly with the Food and Drug Administration offers this helpful note. According to him, "Results of consumer polls are frequently offered in evidence for the purpose of establishing one or another kind of consumer interest or consumer understanding. Such tabulations should be received if the poll was fairly conducted and if it was of a sufficient scope so as to be fairly representative; that is, if the results are such that the ordinary prudent business man would rely on them in making business decisions. A poll planned jointly between government and industry counsel would most likely meet these requirements. Its results should be introduced through a witness who can explain how the poll was conducted."

I might add that in an experimental way we are endeavoring to pursue this type of program in connection with the forthcoming corn standard hearings. A questionnaire has been formulated; a pilot test has been run; and the final questionnaire is in the process of preparation.

Canners Originated Standards Concept

It is hoped that nothing that I have said will be taken to mean opposition to the food standardization program. The concept of a standard of identity and a minimum standard of quality originated with the canning industry and was first incorporated into law in the McNary-Mapes amendment sponsored by the industry.

Perhaps our point of view can best be summarized in a few sentences from the Association's brief in the bean proceeding. In that document we reluctantly found it necessary to be fairly critical of certain determinations made on inadequate data and in our view invalid under the statute. Nevertheless, speaking for the Association, counsel felt it appropriate to point out that the responsibility was jointly that of the Government and the industry. The introduction to the brief concluded with these words: "With all due deference, it is believed that the complicated task of achieving standards of identity and minimum standards of quality, which will both protect the consumer and improve the quality of canned foods and thereby advance the public interest and that of the industry, can be aided and expedited by active industry participation in the standard making procedure. It is hoped that nothing in this brief will be regarded as in any way reflecting upon the scientific capacity or integrity of those engaged in this work in the Food and Drug Administration. The difficulty inherently is one of lack of sufficient data, and in a sense this failure lies at the door of all those who, within the available compass of time and budget, participated in this particular proceeding. The specific issues raised by the resulting record are explored not only because it is believed that the end result is legally unwarranted but also in an effort to suggest improvement in the technique of standard formulation on evidence of record."

DATA ASSEMBLY FOR CORN STANDARDS HEARING

By H. R. Smith, of the N.C.A.'s Washington Research Laboratories

Experience has shown that a large amount of work is necessary in preparation for the formulation of a standard under the Food, Drug and Cosmetic Act. After each hearing almost everyone present wishes that more preliminary work had been done in preparation for the hearing. Part of the preliminary work consists in the study of the legal phases of the matter so that the presentation at the hearing itself will be effective and orderly. The larger part of the preliminary work consists, or should consist, in carefully planned detailed studies of the product itself so that the information brought to the hearing will be adequate for the purpose of establishing a satisfactory standard. This discussion has to do with the efforts that are being made to provide adequate information for the forthcoming public hearing on a standard for canned corn.

The broad subject may be divided into sections for convenient study. The plan is to hold a hearing not only on a standard of quality under the Food, Drug and Cosmetic Act but also to provide a revised standard of identity for all types of canned sweet corn and a standard of fill of container for the different types of canned sweet corn.

DEFINITIONS

(Standards of Identity)

The definitions which are established in connection with standards for food products under the Food, Drug and Cosmetic Act are of greater importance than is generally realized. We have all experienced the confusion that arises when terms are used without a clear, common understanding as to their meaning. There may well be common understanding within the industry as to the significance of certain terms without there being an exact definition of them. Moreover, certain terms that have a definite meaning within a particular industry may have little or no significance to consumers. When terms are to be written into a standard of identity it is necessary for them to be carefully defined.

An even more critical phase of this subject arises from the provisions in the law that only those forms of the product which are defined in the standard may thereafter be packed. It therefore becomes important that every style of pack or method of manufacture be described at the hearing so that the standard will include provisions for the manufacture of not only the usual types of such food but also the special packs. For example the products "Fritter Corn" and "Corn Hearts" have been and are being prepared commercially and if they are to continue to exist the definition for canned sweet corn must contain provisions for these products.

The definitions should be based on a description of the product as sold to the public rather than on any method of preparation. For example, cream style corn should be defined in terms of the characteristics of the final product rather than by describing the method of cutting the corn, especially since there are several methods of cutting corn. It is the duty of the corn canning industry to bring to the public hearing information about all styles of pack and their methods of preparation.

The need for definite meanings for all of the words in the definitions applies likewise to all of the terms used in the standard of quality and the standard of fill of container. The best efforts of everyone should be directed to providing clearly understandable words and definitions throughout the entire standard.

STANDARD OF QUALITY

It should be noticed here that for each kind of food product that is defined there is to be a single standard of quality and that this single standard of quality will apply to all packages of that kind of food. Where a particular food product is prepared by only a few packers in a restricted area from a relatively few varieties the problem of obtaining adequate information is relatively simple. Canned corn, however, is canned by a large number of canners scattered over a wide area from Maine to the state of Washington and down to Texas. There are many commercial varieties of corn, some with quite distinctive characteristics with respect to kernel-size, etc. Canned corn has been prepared for many years and there are different methods of cutting the corn and preparing it for canning which may have an effect on the character of the final product. This large number of variables makes necessary an extensive investigation in order to have adequate information to bring to the hearing. A brief summary of the plan that is being carried out to provide such information should be of interest in opening the discussion.

EXPERIMENTAL PROGRAM FOR 1946

On July 1st and 2nd, 1946 a Corn Standards meeting was held in Chicago. In attendance were representatives of most of the principal corn canning areas of the country, the different state associations particularly interested in this project, The Corn Canners Service Bureau, the research laboratories of the can manufacturing companies, and the National Canners Association. Some idea of the magnitude of the problem was placed before this group and there was full discussion of ways and means for obtaining the necessary information. Finally, the following plan was agreed upon:

Whole Kernel Corn

Samples representing the principal commercial varieties canned in the different areas were to be prepared by the state and regional associations with the assistance of the experiment stations and the Corn Canners Service Bureau. Emphasis was placed on getting samples at the standard and sub-standard levels.

Cream Style Corn

Experimental packs of known history were to be prepared by technologists from the industry, principally from the Research Laboratories of the can manufacturing companies and the National Canners Association.

Vacuum Packed Corn

Samples of corn packed vacuum style and brine style were to be prepared by particular canning firms which are equipped to do this work.

Fill of Container Studies

Each canning factory was to carry on studies with reference to the proper fill of container for the different styles of pack. Particular study is necessary for vacuum packed corn.

Methods of Analysis

The Washington Research Laboratory of the National Canners Association is to confer with technologists from all branches of the industry in an effort to develop satisfactory tests. The Washington Laboratory will also keep in touch with technologists of the Food and Drug Administration with respect to methods of analysis.

Evaluation of the Quality of the Samples

A committee of canners and canned foods technologists representing the corn canning industry will meet and evaluate the samples that have been prepared. This will be done after the analysis of the samples, and the results of the analysis and the evaluations will be correlated to discover any methods which may prove to be reliable as indications of different factors of quality.

The program as outlined above has been carried on thus far with a gratifying degree of success. Samples representing the different areas and different styles of pack have been received and are now undergoing analysis. Various methods of analysis have been considered and a number of them have already been discarded as inadequate. Others appear to show promise and these will be investigated more thoroughly. A final evaluation of the methods cannot be made of course until the samples have been examined by the committee of canners.

Methods of Analysis of Whole Kernel Corn

The alcohol insoluble solids content of the drained corn is the most promising indication of the maturity of the corn. The method is carried on practically as is specified for canned peas. A weighed amount of the drained corn is blended with an equal weight of water in a Waring Blendor for exactly two minutes. Twenty grams of the blended material is weighed out and treated with 200 ml of 80% alcohol by heating to boiling, filtering, etc.

The amount of skin or pericarp is sometimes considered a factor of quality. The samples are being examined for the amount of pericarp by the following method: 50 grams of the blended sample is treated in a beaker with about 200 ml of tap water and the mixture is poured through a 30 mesh screen. The mixture is transferred from the beaker with several portions of tap water and the material on the screen is washed with water from the beaker until practically all of the fine material is through the screen. The screen is finally rinsed in a pan of water by gently shaking the screen in the water so that the material on the screen is loosened and the fine particles can go through the screen into the water. Such gentle treatment for 15 or 20 seconds appears to be sufficient. The material on the screen is then dried for two hours at 100° C and weighed. If the results obtained appear to be promising it may be necessary to further standardize the treatment with the Waring Blendor so that consistent results can be obtained. It is probable that the amount of skin found will vary considerably with the size of the kernels of corn. Certain varieties have small kernels where other varieties are larger and the amount of skin will vary proportionately.

The amounts of total solids, total sugars as invert, and total chlorides as sodium chloride in the samples are being determined so that the results may be calculated in various ways to discover the most satisfactory agreement with the observed quality. It is not possible at this time to indicate which of these determinations may prove to be significant enough to write into the final standard.

The drained weight is determined as is usual in the examination of canned foods and no preliminary washing is necessary (as it is in the case of peas for the A.I.S. determination) since the liquid in canned corn is not perceptibly thick.

The amount of juice expressed with the Succulometer is determined on the drained corn. Results appear to be consistent for the same instrument but if this determination proves valuable it will be necessary to standardize the construction of the test cup for this instrument.

The Succulometer readings vary noticeably with the varieties especially as distinguished by kernel size. Also, vacuum packed corn has a distinctly different range of values from the same corn packed with brine.

The amount of extraneous material in the corn is determined by (1) separating the silk over one half inch in length and recording the total length and the total number of pieces; (2) separating the husk and reporting it as the number of pieces and the total area as measured on a glass plate with ruled squares; and (3) separating the cob and reporting the number of pieces and total volume determined by displacement in water. The off-colored kernels are determined as usual and recorded as percent by count. The determination of what constitutes a "pulled" kernel must be specified more exactly. Kernels without visible signs of cutting may possibly be classified as "pulled" kernels.

Methods of Analysis of Cream Style Corn

Satisfactory tests for the maturity of the corn used in the preparation of cream style corn have not yet been developed. Thus far one or two methods bearing on the general subject of the condition of cream style corn seem to be worthwhile. These are as follows:

Washed, Drained Residue

Cream style corn is considered to be a mixture of cut kernels with crushed corn in a creamy fluid. A definite kernel character is essential. The washed, drained residue indicates the amount of kernels and pieces of kernels that is present. The determination is carried on as follows: 400 grams of the sample is transferred to an eight mesh screen 8" in diameter. The screen and contents are washed gently in a pan of tap water with the water deep enough to come about ¾" above the screen. Gentle agitation loosens the mass of corn so that all of the fine material will sink through the screen. This gentle treatment is continued for 20 seconds and the screen and contents are then lifted out and treated a second time in another pan of water in the same manner and for the same length of time. The screen and contents are then drained for two minutes and weighed as usual.

The washed, drained residue will be examined for alcohol insoluble solids content, pericarp, total solids, total starch and possible other constituents in an attempt to find some measure of maturity.

Consistency

The consistency of cream style corn may be measured in several ways. In every case it is necessary to mix the sample in a uniform manner before making the test. The procedure followed thus far is as follows: The cans are brought to the laboratory room at least 48 hours before the test is to be made so that all of the cans will be uniformly at room temperature. This is quite important. The cans should not be shaken before making the test. Each can is opened and the contents put through a two-mesh screen into a dry pan. If some of the corn is caked in the bottom of the can it should be taken out with a spoon and put through the screen. The material in the pan is then transferred back to the original can with as little stirring as possible and a single determination of consistency is made.

One instrument that has been proved useful is the Stormer Viscosimeter. The regular standard instrument is used and the determination is made on the contents in the can by placing the can on the stand of the instrument, submerging the test cup in the corn, and making a single determination using a 750 gram weight. The number of seconds required for 100 revolutions is recorded as the thickness. The thickness of cream style corn varies from 15 or less to as much as 200 seconds and sometimes more.

The thickness may also be measured on other instruments such as the Adams Consistometer. The test cup is placed in position and filled level full with the mixed sample and a single determination of the extent of the spreading of the mixture on the plate is made. The values on this instrument range only from 4 or 5 to 15 or 16. The harmless extraneous material in cream style corn is determined as indicated for whole kernel corn except that the determination of amount of silk is made on a one ounce sample. The sample is diluted with water and may be separated into a liquid portion and a solid portion by pouring through a small screen. The number of pieces of silk over a half inch long are measured and counted and reported on the basis of pieces per 100 grams.

Information with respect to the amount of foreign material in canned corn must necessarily come from the examination of commercially prepared samples of corn. Obviously extraneous matter in corn is an accident and the occurrence is erratic. A large amount of data is necessary before any conclusions can be reached.

Fill of Container

Presumably the standard of fill of container of cream style corn will be a stated proportion of the total capacity of the can, for example, 90 percent of the total capacity. It may be that for whole kernel corn the drained weight will prove to be a reliable index of the fill of container. But younger corn is lighter than older corn and has a tendency to shrink during processing. This is especially noticeable with vacuum packed whole kernel corn.

"Fill-of-Container" primarily refers to the *volume* of the contents compared to the *volume* of the container. It may be that some procedure for measuring the volume of the corn can be developed—similar to that used

for canned peas. Extensive studies must be made before we can be sure that one method or another is satisfactory under all conditions.

The general procedure is for all methods that show any promise to be tried out sufficiently to see whether they are worthy of investigation. These methods which prove valuable are standardized as far as possible and are tried out by several analysts to establish the reliability of the method.

Evaluation of the Samples

The quality of the samples as to general acceptability for canned products may be determined by several procedures. We have found that if a sufficient number of qualified examiners individually rate a sample for a particular quality the average rating of such a group is a reliable index of the quality. Obviously care must be used in the selection of the group that is to rate the samples to be sure that representatives from different areas and from different groups in the industry shall be included. Another manner of having the samples rated is to have the samples graded by licensed commercial graders according to the existing commercial standards for grades. This is being done in the case of a number of samples being prepared for the public hearing on canned corn.

When the analytical data and the ratings are obtained a statistical analysis will be made of the information to show the degree of reliability of one method or another of examining the corn.

In general, the industry is called upon to make a much more careful examination of its product than has been necessary in the past. It is no fault of the industry that satisfactory information on many of these points was not obtained before the formulation of a standard was contemplated. However, when we come to realize the nature of the standards that are to be prepared we must accept the fact that such specific information must be obtained and each factor of the industry must assume its share of the responsibility for the preparation of adequate data for the hearing.

THE RETENTION OF VITAMIN C IN TOMATO JUICE

L. E. Clifcorn and G. T. Peterson
Continental Can Company
Research Department

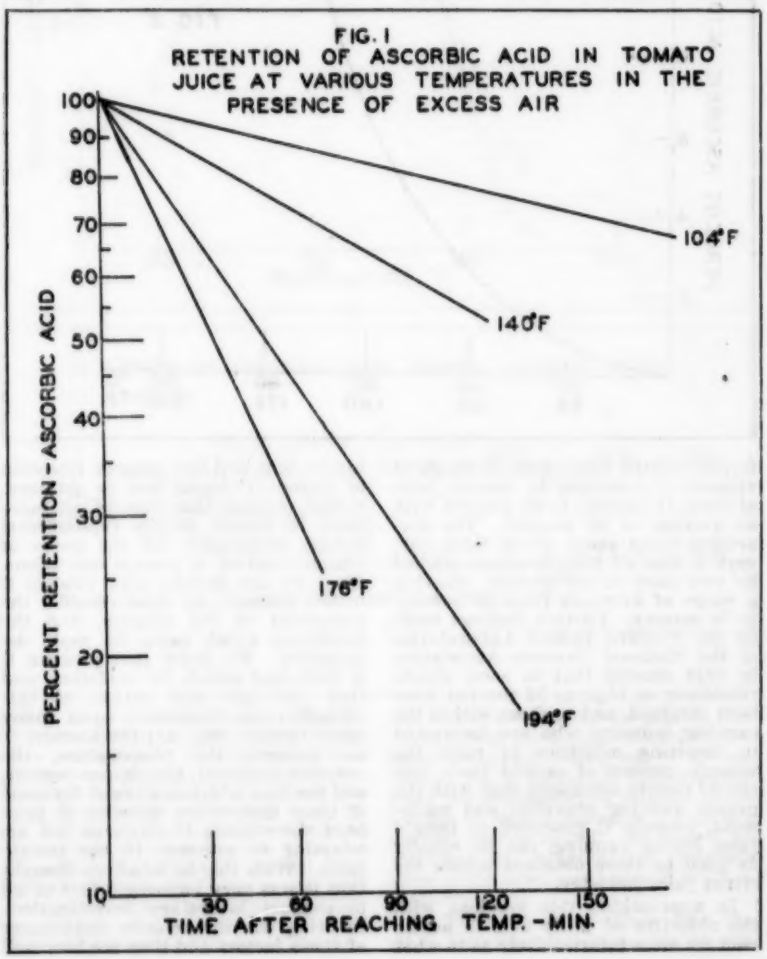
It is generally recognized that the citrus juices and tomato juice are the best sources of vitamin C among canned foods available to consumers today. These products have enjoyed an enlarged popularity because of their high vitamin C content. Many canners are therefore sincerely interested in obtaining an efficient retention of this important vitamin during preparation and canning operations.

Unfortunately tomato juice does not possess as good an environment for the stability of vitamin C during preparation and canning as do the citrus juices. Orange and grapefruit juices containing large quantities of air may be allowed to stand for several hours without appreciable losses of vitamin C, while tomato juice under the same conditions loses large amounts of this important vitamin. Under conditions of heating the differences are even more marked. This has led to investigations by many chemists for the "reasons why," but we must admit that we do not have all the answers today.

Surveys which have been conducted on the role of vitamin C during the canning of citrus juices have generally shown that retentions of over 90 percent from the raw to the canned products are obtained, with retentions of over 95 percent for many of the citrus canning operations. In comparison, surveys made by Guerrant and Associates (1) as a part of the NCA-CMI Nutrition Program, on the effect of canning operations on the vitamin C content of tomato juice have indicated a range of retention from 52 percent to 80 percent, with an average of 70 percent for the six Eastern canneries studied. From information received from the American Can Company Research Laboratories, they have found in their plant surveys a range of retentions from 40 percent to as high as 90 percent, with the average around 70 percent. Investigations (2) conducted by our laboratories during 1943 and 1944 have resulted in findings showing a range of retention from 51 percent to 79 percent with an average of 69 percent.

Comprehensive surveys made by the Western Branch Laboratories of the National Canners Association in Cali-

FIG. 1
RETENTION OF ASCORBIC ACID IN TOMATO JUICE AT VARIOUS TEMPERATURES IN THE PRESENCE OF EXCESS AIR



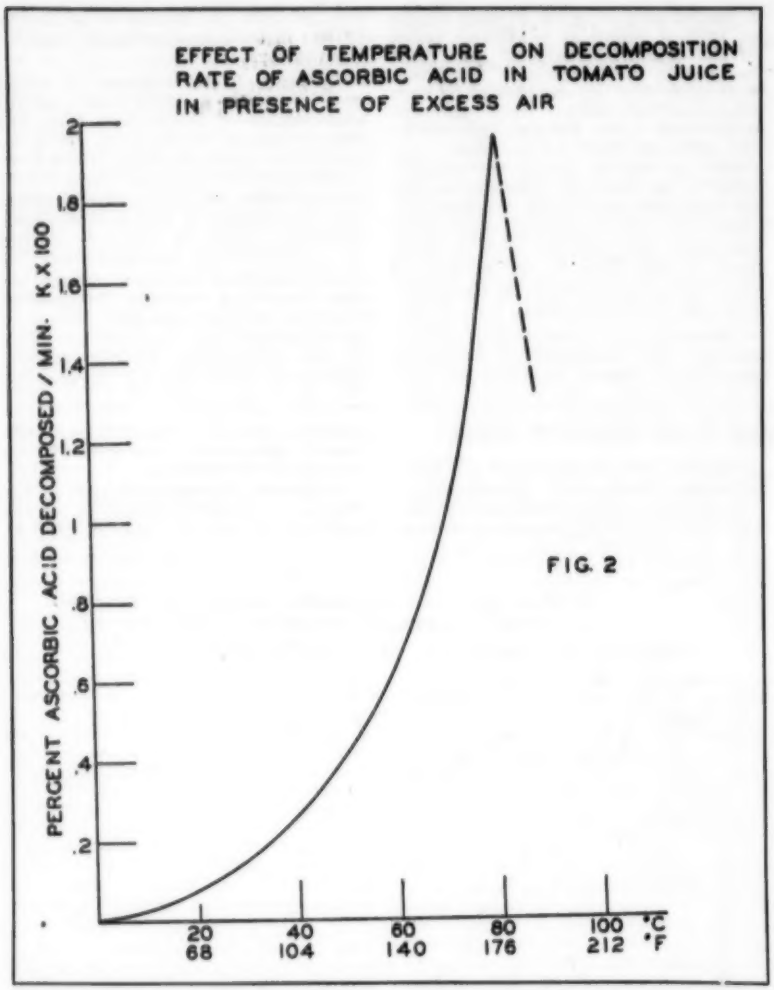


FIG. 2

fornia in 1943, have shown a range of vitamin C retention in tomato juice of from 11 percent to 81 percent with an average of 63 percent. The surprising thing about all of these surveys is that all the retentions studied lie very close to one another, showing a range of averages from 63 percent to 70 percent. Further findings made by the Western Branch Laboratories of the National Canners Association in 1944 showed that in some plants retentions as high as 94 percent have been obtained, and to those within the canning industry who are interested in inspiring activities to raise the vitamin content of canned foods this should clearly emphasize that with the proper canning practices and equipment, vitamin C retention in tomato juice during canning, can be equally as good as those obtained within the citrus juice industry.

In approaching this problem, with the objective of being able to advise canners more informatively as to what can be done and how greater retention of vitamin C might best be obtained, it was obvious that first of all more must be known of the fundamental factors responsible for the losses of vitamin content in present operations. Since we are dealing with vitamin C in this instance, we must consider the properties of the vitamin, and the conditions which cause its rapid destruction. We know that vitamin C is destroyed mainly by oxidation, and that the rate and extent of this oxidation are dependent upon many other factors, such as; the amount of air present, the temperature, the enzymatic content, the copper content, and the time which is allowed for some of these destructive elements to bombard the vitamin C which we are attempting to preserve in the tomato juice. With this in mind we thought that it was very important first of all to conduct laboratory investigations to bring out the relative importance of these factors and then see how well these laboratory findings correlated with observations made in plant surveys. If this were accomplished with exceptionally good correlation we would have a firm background upon which to recommend improved canning practices for greater vitamin C retention in tomato juice.

Since the temperature to which raw tomato juice is heated in the presence of air was thought to be important in the rate of vitamin C destruction, tests were run in which the juice was heated at various temperatures in the presence of an excess of air. The temperatures used were 104°F., 140°F., 176°F., and 194°F. The retention of vitamin C at these temperatures for varying lengths of time (0-150 min.) was determined with results as shown in Figure 1. Since the values of vitamin C expresed as percent retention provide curves with a fairly consistent slope, they were considered typical of a "first order reaction" and the following formula applied:

c—concentration of vitamin C
t—time

$$\frac{dc}{dt} = k$$

To obtain a workable equation, the above mathematical equation was integrated to give:

$$k = \frac{2.303}{t} \log \frac{a}{a-x}$$

Here a is the initial concentration of vitamin C, x is the amount reacting in time t, and $a-x$ is the concentration remaining after time t. The quantity k is called the velocity constant, or specific reaction rate. It has the dimensions of a number per unit of time. For example, from the above mentioned data when k has a value of 0.01, the material is decomposing at the rate of 1 percent per second. The results of these calculations are plotted in Figure 2.

Since the possibility of enzymes influencing the above results was raised, another test was devised in which part of the raw tomato juice was quickly heated to 200° F. to inactivate the enzymes and then cooled to each of the temperatures used in the test. These were compared to similar raw tomato juice which had not been so treated to inactivate the enzymes. These results are shown in Figure 3.

As will be observed, the rate of vitamin C destruction in tomato juice saturated with air varies directly with increases in temperatures up to a maximum of 186° F. Then to our great surprise, with further increase in temperature a sharp drop in the rate of vitamin C destruction was noted which was verified by further work on another lot of tomato juice. We may conclude that in the presence of air the rate of vitamin C destruction increases with increase in temperature, and in heating to a temperature of 190°F. or above, one must heat as quickly as possible, in order to avoid rapid loss of vitamin C at the intermediate temperatures.

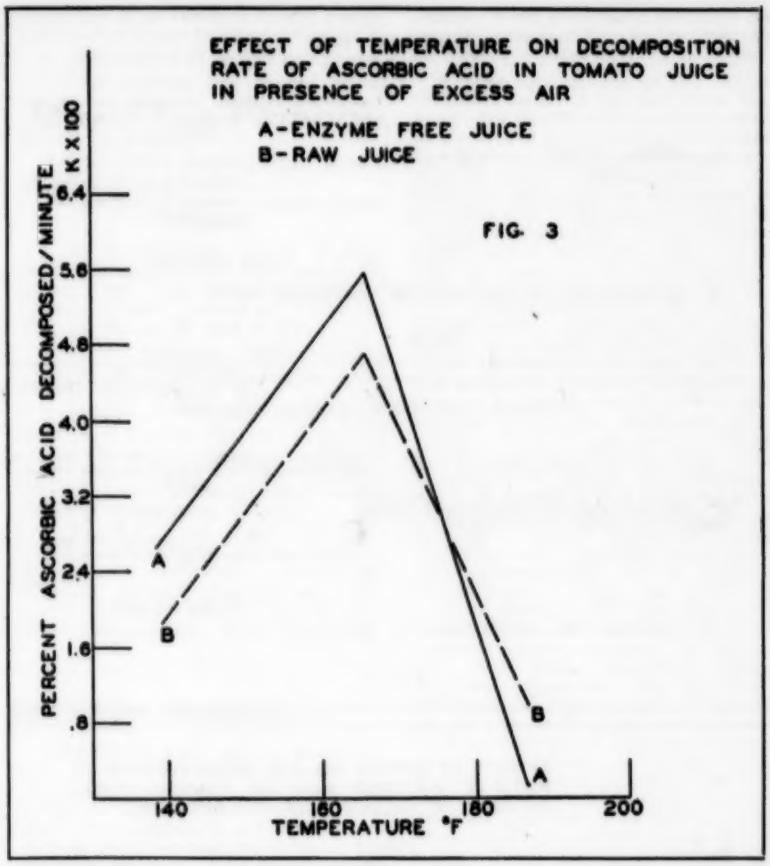
It is important to add that no explanation which we have offered for this unusual rate of destruction at the higher temperatures has proved to be satisfactory. We are still very curious to know why this specific change in rate of destruction occurs. Since the rate of destruction of vitamin C was not greater in the raw juice than it was in the heated juice, as shown in Figure 3, this definitely indicates that there are no appreciable quantities of heat labile vitamin C-destroying enzymes in tomato juice. This is further verified by the work reported by F. C. Lamb, Western Branch Laboratories, N.C.A. (3), (4) in which he shows no destruction of vitamin C attributable to enzymatic action, and further shows that if there are vitamin C-destroying enzymes in tomato juice they are most likely so firmly bound up in the skin and other insoluble materials in the juice that they do not all get into the juice, and that there is apparently no danger of obtaining a juice of high enzyme content during commercial extraction operations.

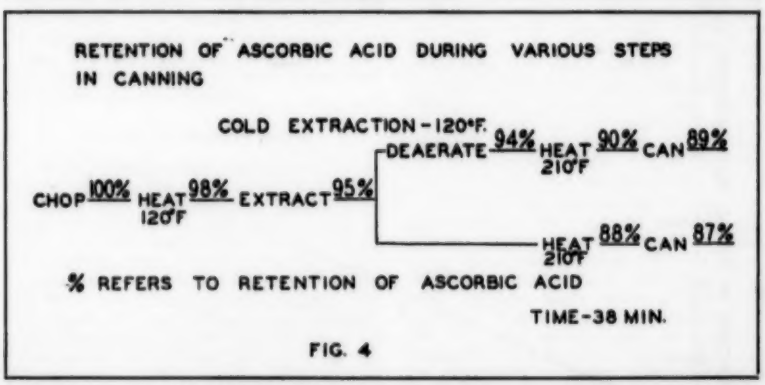
In connection with the above results it is important to understand that since vitamin C losses are directly related to oxygen or air content of the juice, and that since under these conditions the rate of loss is dependent upon the temperature of the juice, the complete exclusion of air from the juice, and the handling and holding at low temperatures of tomato juice containing air are necessary to be concordant with good practice.

The question of cold extraction versus hot extraction of tomatoes in the production of tomato juice so far as vitamin C retention is concerned has been a subject of considerable debate. For purposes of clarity in this work we have defined cold extraction as that which produces juice with a temperature of 120° F. or below. Laboratory studies, carried out as shown in Figures 4 and 5, showed that the cold extraction method had some advantage over hot extraction, particularly when the product was not deaerated. When deaeration immediately after extraction was employed these differences were minimized, as could be expected.

In commercial practices the results of 12 surveys of hot break procedures showed that there was an average retention of 84 percent of the original vitamin C content immediately after extraction, while similar studies, including 6 surveys of cold break tomato juice canning operations, showed an average of 94 percent retention in the extracted juice. However, from these studies it was shown that the average over-all retentions from hot and cold methods were almost identical, which is explained by the fact that there were also many varied practices in handling both hot and cold juice after it was extracted, so that the advantages of any one method were obscured. The important thing for the canner to realize in this connection is that he can obtain a higher vitamin C content in tomato juice immediately after extraction by the cold extraction process and that if he wishes to retain this high vitamin C content he must do one, or preferably both of the following: *deaerate to eliminate the oxygen* and handle the juice in subsequent operations to prevent further incorporation of air, or *heat the juice as quickly as possible to a high temperature for immediate canning.* These fundamental principles also apply to hot extracted juice and in this regard need particular emphasis, because the juice coming out of the extractor has a particular disadvantage from the standpoint of vitamin C retention in that it contains a high air content and it is hot. As shown by Figure 3, the temperatures approach those of the most rapid rate of vitamin C destruction.

In Figure 6 it is shown that the most desirable method so far as our





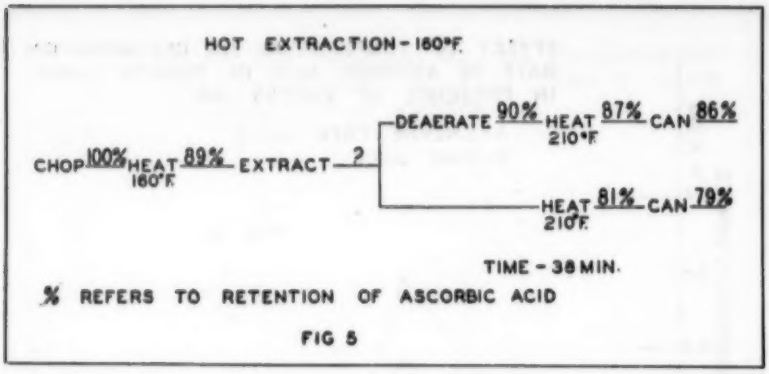

HOT EXTRACTION - 180°F.
CHOP 100% HEAT 180°F. 89% EXTRACT 2
DEAERATE 90% HEAT 210°F. 87% CAN 86%
HEAT 210°F. 81% CAN 79%
TIME - 38 MIN.
% REFERS TO RETENTION OF ASCORBIC ACID

FIG 5

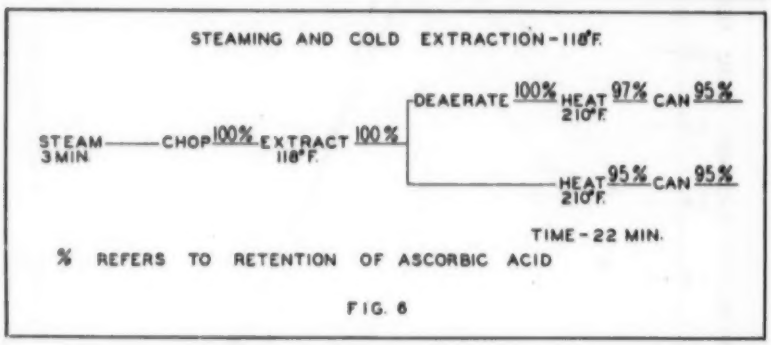
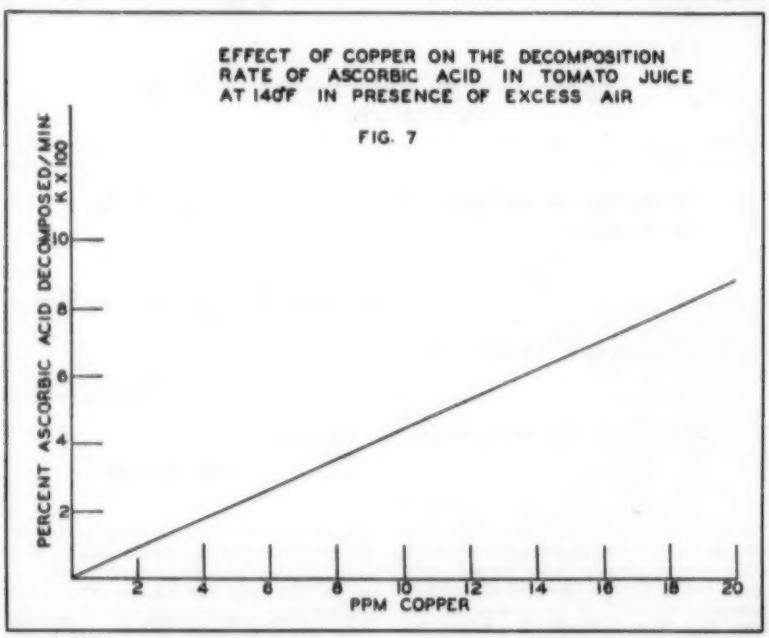

STEAMING AND COLD EXTRACTION - 118°F.
STEAM 3 MIN
CHOP 100% EXTRACT 118°F. 100%
DEAERATE 100% HEAT 210°F. 97% CAN 95%
HEAT 210°F. 95% CAN 95%
TIME - 22 MIN.
% REFERS TO RETENTION OF ASCORBIC ACID

FIG. 6



laboratory work is concerned is that of steaming the tomatoes for 3 minutes after which they are extracted without further heating. These operations followed by kettle heating and canning resulted in a retention of 95 percent of the vitamin C even though the lapse of time amounted to 22 minutes for all of the operations. There seems to be some particular advantage of steaming tomatoes and using cold extraction, which is concordant with observations made by Lamb and Associates, who also observed that more vitamin C was released into the juice as a result of the pre-steaming operation.

Investigations were carried out on the rate of vitamin C loss in tomato juice as affected by copper. These tests were made on raw tomato juice at 140° F. in the presence of excess air. Figure 7 shows the results obtained. It will be observed that copper is extremely destructive to vitamin C in the presence of air and the destruction rate increases with increase in copper content. The destruction of vitamin C encountered in commercial practices is often the result of the use of copper equipment in some form in the plant.

Vitamin C Retention Results

For matter of comparison with the above laboratory experimental work, the following surveys of actual cannery practices are presented. In table I, results of vitamin C retentions are indicated where canning practices were considered unsatisfactory. In this case, hot break procedures were employed, the extracted juice was pumped over long distances, held in a number of holding tanks, particularly after being heated, and the whole canning cycle was quite long. Unfortunately, the exact time cycle was not obtained, but it is estimated to be in the neighborhood of 30 to 40 minutes. Also copper equipment was used at various places in the cannery operations. As was expected from the equipment and practices employed, a low over-all retention of 51 percent of the original vitamin C content was found.

Table No. 1

RETENTION OF ASCORBIC ACID DURING CANNING OF TOMATO JUICE IN PLANTS WHERE POOR PRACTICES WERE EMPLOYED

Sampling Station	Percent of Retention
A. Fresh whole tomatoes	100
B. Fresh chopped tomatoes	91
C. Preheating tank (copper) 158° F.	74
D. Extracted, holding tank (copper) before heating to 205° F.	71
E. Filled and closed 187° F.	49
F. Processed 30' @ 212° F., water cooled	51

Ascorbic Acid Retention

In table II, cannery A (3) had a very efficient setup including deaeration, in which the whole canning cycle was completed in 2 to 3 minutes. In this case the tomatoes were extracted cold, heated rapidly to 180° F. to 190° F., deaerated immediately under a vacuum of 12 inches, heated in a tubular sterilizer to temperatures of 227° F. to 230° F., filled and closed, and air cooled. While some question might be raised as to the advisability of preheating the juice prior to deaerating, it seems satisfactory in this case, because the time required for

heating the juice to 190° F. prior to deaeration was extremely short.

Table No. II

RETENTION OF ASCORBIC ACID DURING CANNING OF TOMATO JUICE IN PLANTS WHERE GOOD PRACTICES WERE EMPLOYED

*CANNERY A

Sampling Station	Percent of Retention
Raw, juiced	100
From finisher	97
After closing	91
After cooling	90

* Total elapsed canning time 2 to 3 minutes.

In summarizing, the following principles have been found to be concordant with practices which we believe could be employed to bring the retention of vitamin C in tomato juice to very high and satisfactory levels:

1. Steaming of tomatoes prior to extraction.

2. Cold extraction of tomatoes.

3. The elimination of as much air as possible during operations subsequent to extraction.

4. Heating of the juice to its top temperature as quickly as possible.

5. If storage tanks are necessary to provide full capacity, it is preferable to hold cold juice rather than heated juice, and in no instance should heated juice which is not freed of air, be held.

6. Elimination of copper equipment.

7. The canning line should be as simple as possible and unnecessary pumping or handling of the juice should be avoided.

8. The whole canning time should be as short as possible.

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STATUS OF INDUSTRY NUTRITION PROGRAM

By J. Russell Esty, Director, N.C.A. Western Branch Research Laboratory

Starting in May, 1942, the N.C.A.-C.M.I. Nutrition Research Program has progressed along the lines originally outlined, namely:

Examination of commercial packs from the 1942-1943 and 1943-1944 seasons, and on fish from the 1946 pack, for vitamin and mineral contents, also protein, carbohydrate, etc., to determine the proximate composition;

Effect of cooking on the vitamin content as the food is prepared for the table;

Effect of storage temperature on the vitamin content, also warehouse temperatures;

Distribution of nutrients between solids and liquid;

Comparison of vitamin values obtained by different methods of assay; and

Changes in the vitamin content of foods during caning. This latter has included studies on the effect of holding raw products prior to canning, effect of duration and temperature of blanch on the vitamin retention by certain vegetables, a study of the progressive inactivation of enzymes in certain vegetables during blanching, and chemical changes occurring in them during blanching and subsequent holding.

As a result of the studies made during the five-year period, reliable information concerning the nutritive value of canned foods as now produced commercially is available. Much of it already has been published in the scientific journals. In a few instances the work is in manuscript form or awaiting publication. To date, twenty-four scientific articles have been submitted for publication and seventeen of these are now in print.

Location of Research Studies

With the exception of some of the canning studies, the work has been carried out in research laboratories not connected with the canning industry. In this connection, it should be mentioned that research on this program has been conducted continuously at the Pennsylvania State College, Department of Agricultural and Biological Chemistry, under the direction of Professor N. B. Guerrant, and at the University of Wisconsin, Department of Biochemistry, under the direction of Professor C. A. Elvehjem. The other institutions which have participated are Department of Home Economics and Household Administration, University of Chicago; Division of Food Science and Technology, N. Y. State Agricultural Experiment Station, Cornell University; Department of Horticulture, University of Maryland; Department of Horticulture, Michigan State College; and the Biochemical Institute, University of Texas. Each institution has made important contributions to the program on nutritive value of canned foods.

A year ago, at one of the N.C.A. technical sessions, the Nutrition Program was described by three members of the Nutrition Executive Committee. Dr. Pilcher gave the background and plan of the research program. Dr. Clifcorn presented a statement of progress and I discussed certain objectives including part of the publicity program. A report of these papers may be found in the Supplement to the N.C.A. INFORMATION LETTER No. 1073, published February 12, 1946. It is, therefore, unnecessary to review again the program prior to January, 1946. During the past year, the work has consisted mainly of projects carried on at the University of Chicago, Cornell University, Michigan State College, Pennsylvania State College, and the University of Wisconsin. The programs at Cornell and Michigan State on handling raw products prior to canning and chemical changes occurring in certain vegetables during blanching and subsequent holding are nearing completion. At the Pennsylvania State College the blanching studies started in 1945 have been completed, and a scientific report has been submitted for publication. In connection with these blanching studies, work was also done at the University of Maryland with the main emphasis on proteins, carbohydrates and minerals, and effects of duration and temperature of blanch. A report of this work is in manuscript form. The University of Wisconsin has been working on vitamin assays of the following seafoods: mackerel, salmon, sardines, and tuna. These include studies on the newer B vitamins. It appears that the methods now generally considered suitable for food products will be satisfactory for the seafoods with the exception of those for folic acid and vitamin A. Concerning the latter, there appear to be interfering substances, and carotenoids should also be considered. The University expects to complete the assays by July 1.

The studies on effect of storage temperature on the vitamin content, conducted at the University of Chicago and the Pennsylvania State College, will be concluded early this year. This will include tests over a 24-month period. The storage temperatures are 50, 65, and 80° F. and in addition, samples were held in nine warehouses to represent storage conditions prevailing in various parts of the country.

Thirty Articles on Nutrition

With the completion and publication of work now in progress, there will be at least thirty scientific articles in print from this program.

During 1947, two new projects will be started. One will be conducted at the Pennsylvania State College on the stability of ascorbic acid during storage and the relative accuracy of

the several methods for ascorbic acid estimation now being used. As an indication of the nature of this work, it is hoped to obtain information concerning the following points:

1. Is there a steady decline in ascorbic acid content of canned citrus juices with low initial headspace oxygen content, or is there a "break-point" in the early days or weeks of storage?

2. What influence, if any, do metals, which might be acquired from equipment or from metal containers, have on the rate of decline of ascorbic acid in canned citrus juices?

3. What is the behavior of ascorbic acid in canned citrus juices packed with abnormally high headspace oxygen?

4. What are the stabilities of ascorbic acid in canned citrus juices, and in a juice prepared from a low-acid food, such as spinach, after opening and during open storage at normal refrigeration storage temperatures?

5. Is there any practical method of preventing decline of ascorbic acid during storage of canned foods other than by low-temperature storage?

The other new research project will probably be conducted in several institutions. It has to do with the influence of the canning process upon protein, with special attention to seafoods and, possibly, meat products. To begin with, it is planned to determine the influence of temperatures such as those involved in canning upon the nutritive value of protein. This would, in all probability, include a study of the thermo-stability of the individual amino acids at different temperatures and the protection, if any, which may be offered amino acids when in peptide and polypeptide form.

In addition to those projects, a cooperative study with interested canning equipment manufacturers on vitamin retention is under consideration. This may involve, for example, the redesigning of such equipment as that needed for blanching. A meeting is to be held on January 23, 1947 with the canning equipment companies to inaugurate this program.

Publicity on Nutrition

Mention was made last year of the non-technical publicity which the Home Economics Department had arranged with the magazine, *What's New in Home Economics*, a magazine especially well received by Home Economics teachers. The one-page editorial ads have appeared monthly, during the school year, since April, 1946. It may interest you to know the nature of the material presented. The subjects and time of appearance are as follows:

	1946
April	"Canned Foods Contribute Toward Adequate Diet."
May	"The Importance to You of Vitamins in Canned Foods."
June	"Canned Foods Supply the Necessary Minerals for Body Building."
September	"Why Use the Liquid from Canned Fruits and Vegetables?"
October	"The Nutritive Value of Canned Fruits in Supplying Important Vitamins in our Diets."
November	"How Proper Preparation is Important to the Nutritive Value of Canned Vegetables."
December	"Dietary Importance of Canned Juices in Providing Necessary Vitamins."
	1947
January	"Nutritive Value of Canned Sea Foods Takes on New Importance."
February	"Canned Food Specialities."
March	"Support Bouyant Health Through Proper Selection of Canned Foods in the Daily Diet."

The Home Economics Department informs me that up to December they had received more than 30,000 requests for these releases.

Another part of the 1947 program is the preparation of a N.C.A. bulletin covering the work done to date on the nutritive value of commercially canned foods. It is planned to make this bulletin an authoritative up-to-date reference source on this subject. It will include a brief history of the science of nutrition, the nutritive requirements, utilization of canned foods, and a summary of the findings made by the universities and colleges cooperating in this program during the past five years. It will be a collaborative effort, with representatives of the Research Laboratories of the N.C.A., the American Can Company, and the Continental Can Company participating.

A year ago, I stated that "As a result of the work done through this Nutrition Program, there is every reason to expect that by proper application of the principles being established in many instances the nutritional values of canned foods can be materially improved without additional expense to the canner and without impairing the other qualities of the final product". Recently, in an address on "The Relationship of the Canning Industry to Better Human Nutrition", Professor N. B. Guerrant, referring to this program and what the future holds in store in the way of developments, stated:

". . . it is my frank opinion that one of the most promising fields of research, leading to future improvement in canned foods and thereby in the canning industry, lies in those developments which will bring about a canned product of maximum nutritive value. In general, this objective may be accomplished in two ways, namely, (a) by a more efficient conservation of the nutrients normally present in the natural foods of today, and (b) by developing foods of greater nutritive value through genetics, fertilization and by production in special localities under optimal environmental conditions.

"In regard to the first procedure it can be said that the studies of Kohman and co-workers and those which are being carried out under the N.C.A.-C.M.I. Nutrition Research Program have yielded data which have been both valuable and enlightening, but as yet these data have served primarily to demonstrate the need for additional researches along these lines, and have not in themselves solved the problem. For example, in the instance of canned foods it has been adequately demonstrated that tremendous loss of nutrients takes place between the time the food leaves the field or the tree and when it arrives on the plate of the consumer. Some of these losses are known to take place during harvesting and transportation to the cannery, during preparation for canning, during processing, during subsequent storage, and during preparation preliminary to consumption. Furthermore, some information is at hand to show which ones of this chain of manipulations are the most obstructive to higher nutritive value. The solution apparently is one of better harvesting methods, better handling and storage conditions, more careful selection and preparation for processing, improved processing machinery, improved processing methods, improved warehouse facilities, and better cooking and serving methods. In this connection, it may be well to state that it is recognized that in order to receive public acceptance, canned foods must possess desirable characteristics other than nutritive value. However, to my knowledge, there are no scientific data to show that it is not possible to produce canned foods having these desirable characteristics and also possessing high nutritive value."

SOME FACTORS AFFECTING HEAT PENETRATION IN TOMATOES

By H. L. Roberts, H. A. Benjamin
Research Division, American Can Company

About 20 years ago, the National Canners Association Research Laboratory under the direction of the late Dr. W. D. Bigelow carried out extensive tests on the processing of tomatoes. Results of this work were reported at the annual convention in 1926 and culminated in the printing of National Canners Association *Circular No. 15-L* entitled *Processing and Cooling of Tomatoes*. In this circular, the following still processes were sug-

gested for whole tomatoes under different packing conditions:

Can Size	Processing times at 212° F. Water cooled	Air cooled
#2	45 minutes	35 minutes
#3	55 minutes	45 minutes
#10	90 minutes	70 minutes

Experience has shown these processes to be fundamentally sound as spoilage due to under-sterilization has been negligible under average commercial conditions when these cooks were used. It was realized at that time that there was a number of factors which would influence heat penetration in tomatoes and therefore the required process. Seach of the literature does not indicate that any attempt has been made to identify the factors affecting heat penetration.

In view of the apparent static condition of available knowledge concerning tomato processing, it seemed desirable to conduct further experiments to measure the effect of various factors on the rate of heat penetration in canned tomatoes. Arrangements were made at several typical canning plants for carrying out the necessary heat penetration tests.

Experimental

The heat penetration technique consisted of measuring can center temperatures at periodic intervals during the processing of tomatoes. A thermocouple was affixed to the side of a can in such a manner that the hot junction was located at the geometric can center. Whole tomatoes were then hand packed into these cans and an attempt made to embed the thermocouple hot junction within a solid tomato. After filling, the cans were exhausted, closed, and processed in the prescribed manner. Heat penetration was measured on 109 No. 2 cans and 93 No. 10 cans under various controlled conditions. The effects on heat penetration of the following factors were studied: (1.) Drained weight or fill, (2.) Initial temperature as related to type of exhaust used, (3.) Firming agent, (4.) Maturity, and (5.) Processing medium.

Factors Affecting Heat Penetration

The results obtained with each of these factors are given and discussed in the subsections which follow. The tables include two indices of heat penetration, i.e., can center temperatures at the end of the processes suggested by the N.C.A. laboratory, and times to reach specified temperatures. These specific temperatures are 170°F. and 190°F., which are sometimes used as a basis for establishing processing times for air cooling and water cooling, respectively.

Drained Weight—A summary of the data obtained with drained weight as the variable is given in Table I.

The heating rate observed in No. 2 cans of whole tomatoes does not appear to be measurably affected by differences in drained weights within commercial limits. On the other hand, the heating rates in No. 10 cans were markedly affected by differences in drained weight. There is a possibility that the differences observed in the case of No. 10 cans were due more to thermocouple position than to the variable under consideration. The tightly packed heavily filled cans may have maintained the thermocouple firmly in the tomatoes, while the looser packing attending the lighter fills may have allowed the tomato to slip off of the thermocouple or to have loosened sufficiently to create a channel along the thermocouple stem to the hot junction.

Table I

EFFECT OF DRAINED WEIGHT ON PROCESSING REQUIREMENTS

Can Size	Dr. Wt.	Grade[a]	No. Cans	Process time to reach 190° F. Maximum	Minimum	Av.	Temp. at end of N. C. A. cook[b] for water cool Maximum	Minimum	Av.
	Oz.			*Min.*	*Min.*	*Min.*	*°F.*	*°F.*	*°F.*
307x409	13.5 -14.5	A	34	60	35	54	194	174	183
307x409	12.0 -13.5	B	26	60	33	52	203	175	186
307x409	10.25-12.0	C	12	61	32	52	208	174	185
603x700	72.25-76.5	A	8	170	100	130	187	150	171
603x700	63.5 -72.25	B	27	150	40	111	210	158	181
603x700	54.75-63.5	C	7	150	48	70	209	166	200
603x700	50.0 -54.75	D	3	70	60	65	210	197	203
				—To reach 170° F.—			—For air cool—		
307x409	13.5 -14.5	A	38	46	30	38	178	156	168
307x409	12.0 -13.5	B	26	43	19	38	194	154	165
307x409	10.25-12.0	C	19	44	23	37	198	153	161
603x700	72.25-76.5	A	16	125	70	83	174	133	158
603x700	63.5 -72.25	B	31	111	40	80	210	141	165

[a]Basis drained weight required by U. S. Standards for Grades. [b]Average exhaust times added—2 min. for No. 2 cans, 5 min. for No. 10 cans.

Table II

EFFECT OF EXHAUSTING PROCEDURE ON PROCESSING REQUIREMENTS

Can Size	Type Exhaust	Grade[a]	No. Cans	Process time to reach 190° F. Maximum	Minimum	Av.	Temp. at end of N. C. A. Cook Maximum	Minimum	Av.
				Min.	*Min.*	*Min.*	*°F.*	*°F.*	*°F.*
307x409	Steam Flow	A	8	59	33	49	201	176	184
307x409	Thermal	A	8	50	34	40	199	187	194
307x409	Steam Flow	A	8	60	43	55	188	170	176
307x409	Thermal	A	7	50	33	43	197	186	191

[a] Basis drained weight as required by U. S. Standards for Grades.

Effect of the Exhaust

The effect of the exhaust procedure on the process requirement of tomatoes is to change the initial temperature which, in turn, affects the process time required to attain a given can center temperature. Obviously, steam exhausted cans have a higher initial temperature than steam flow-closed cans which have not been thermally exhausted. It would appear that the addition of a time equal to the steam exhaust time to the process would be adequate for steam flow-closed cans. However, approximately ten minutes additional processing time was required for the steam flow-closed cans to attain the same can center temperature as in the steam exhausted cans. This condition obtained in spite of the fact that the steam exhaust was only four minutes.

The two sets of data shown in Table II are from different canning plants. Data from No. 2 cans only are available. It should be mentioned that the steam exhausting procedure was carried out in a still retort since commercial exhaust boxes were not available in the plants visited. It is quite possible that conventional exhaust boxes would have a somewhat different effect as a transfer time of ten to fifteen minutes was necessary, during which time the can center temperature undoubtedly continued to rise from the heat imparted during exhausting.

Effect of Firming Agent

For several years some tomato packers have used the Kertesz process in which calcium chloride is employed to help keep canned tomatoes firm and whole. The calcium is generally added in the form of tablets containing 20 percent calcium chloride and 80 percent sodium chloride. These tablets, 30 grains for the No. 2 cans and 150 grains for the No. 10 cans, were used in our tests to study the effect of calcium salts on the rate of heating in canned tomatoes.

The data obtained in these tests indicate that in general tomatoes with added calcium tend to heat somewhat more slowly than tomatoes without added calcium. This effect appears to be more pronounced in No. 10 cans than in No. 2 cans, as is shown in Table III.

In interpreting the data shown in Table III, consideration should be given the number of cans involved in each test. For instance, a substantial difference in heat penetration is indicated in No. 10 cans for the treated and non-treated tomatoes. In one

Table III

EFFECT OF ADDED CALCIUM ON PROCESS REQUIREMENTS

Can Size	Calcium added	Grade*	No. of Cans	Process time to reach 190° F. Maximum *Min.*	Minimum *Min.*	Av. *Min.*	Temp. at end of N. C. A. cook Maximum °F.	Minimum °F.	Av. °F.
307x409.....	No	A	12	60	33	51	194	174	184
307x409.....	Yes	A	15	60	45	56	192	174	182
307x409.....	No	B	12	59	33	50	203	175	188
307x409.....	Yes	B	10	60	43	53	190	177	184
307x409.....	No	C	8	61	22	52	208	174	185
307x409.....	Yes	C	4	55	48	53	189	179	183
603x700.....	No	A	2	112	100	106	187	180	184
603x700.....	Yes	A	6	170	110	140	183	150	167
603x700.....	No	B	10	135	73	92	201	166	185
603x700.....	Yes	B	13	150	40	100	210	158	178

* Basis drained weight as required by U. S. Standards for Grades.

Table IV

EFFECT OF MATURITY ON PROCESSING REQUIREMENTS

Can Size	Maturity	Grade*	No. of Cans	Process time to Reach 190° F. Maximum *Min.*	Minimum *Min.*	Av. *Min.*
307x409.....Green cores		A	8	55	35	50
307x409.....Red ripe		A	8	59	33	49
603x700.....Green cores		C	2	60	49	55
603x700.....Red ripe		C	4	75	48	55

* Basis drained weight as required by U. S. Standards for Grades.

Table V

EFFECT OF PROCESSING MEDIUM ON PROCESSING REQUIREMENTS

Can Size	Grade*	Processing Medium at 212° F.	No. of Cans	Process time to reach 190° F. Maximum *Min.*	Minimum *Min.*	Av. *Min.*
307x409.....	A	Water	15	60	48	56
307x409.....	A	Steam	16	60	33	52
603x700.....	B	Water	16	150	90	125
603x700.....	B	Steam	9	112	40	88

* Basis drained weight as required by U. S. Standards for Grades.

case, especially, only two cans were tested. It is quite likely that had a larger number of cans been included for this condition, the difference in indicated heat penetration would have been substantially less. Although a tendency for the treated tomatoes to heat more slowly is indicated, these data are not regarded as sufficiently conclusive to warrant a general recommendation of higher processes for calcium treated tomatoes.

Effect of Maturity

From the limited number of tests made, it appears that the maturity of fruit does not significantly influence the rate of heat penetration in canned tomatoes. Red ripe fruit and fruit having a somewhat green core were used in these tests. The heat penetration data are summarized in Table IV.

The grades shown in Table IV, as in the previous tables, are based solely on the drained weights of the cans tested. The differences in heat penetration shown for the different maturities are not considered to be significant.

The Effect of Processing Medium

It is well known that tomatoes processed in an agitating type cooker require less time than when processed in a still retort. The reason for this is presumed to be a result of faster heat penetration because of mixing of the can contents during the agitated process. Tomatoes which are processed in boiling water may be subject to some agitation by the ebullition of the boiling water. The possibility existed that boiling water would cause tomatoes to heat faster than steam because of the slight agitation which would be imparted to the cans in a boiling water bath. Controlled tests were made to check this possibility by comparing water bath and steam processes at the same temperature. The heat penetration data obtained in these tests are shown in Table V.

The above data do not indicate that boiling water resulted in faster heat penetration; on the contrary, steam processing appears to result in faster heat penetration. The reason for this difference is not entirely clear but it probably is associated with extreme variation in heat penetration found in this product and the small number of cans involved in these particular tests. This factor should be given further study before definite recommendations can be made.

Discussion

Perhaps the most significant thing apparent in the data quoted above was the extreme variation in heat penetration for cans packed under supposedly identical conditions. There is possibly a number of factors contributing to these differences. The fact that such differences are observed casts considerable doubt on the validity of determining processes for tomatoes on the basis of can center temperature measurements. The measurement of the temperatures within a few cans cannot be relied upon as being representative of temperatures in the whole pack. The particular cans measured may have been either slow or fast heating and not at all suitable for the standardization of the process for the whole pack.

It will be noted that the N.C.A. suggested processes which have been used successfully for a long period of years result in can center temperatures as low as 150°F. in slow heating cans. The commercial success of these cooks is consistent with facts known about typical microorganisms usually causing spoilage in tomatoes; such organisms have thermal death times of only a few minutes at 160°F. and have not been found to survive even a few seconds at 190°F.

If can center temperatures are to be used as a basis for establishing processes it would appear that the average temperature in a set of cans taken at random should be at least 190°F. for water cooling and 170°F. for air cooling in order that the slow heating cans will be sure to attain lethal temperatures for the necessary time.

In cases involving wide variations in heat penetration the testing of a large number of cans is desirable; further study of heat penetration in whole tomatoes is necessary for evaluating more accurately the effect of various conditions on the processing requirements.

Summary

The effects of drained weight, initial temperature (thermal exhaust vs. steam flow closure), use of calcium salts, maturity and processing medium (steam vs. water) on heat penetration in tomatoes have been studied for both No. 2 and No. 10 cans. Wide variations in heating rate were found within any one variable in cans packed as nearly identically as possible, which largely nullified the differences between variables.

Comparison of thermally exhausted tomatoes with tomatoes closed cold with steam flow exhaust shows that allowance in processing time is required for the cold closure procedure, perhaps in excess of the time of thermal exhaust practice. Further

study of this variable is required to establish the optimum allowance needed.

Because of the wide range of heating rates observed, the establishment of tomato processes on the basis of random can center temperature measurements appears to be an uncertain proposition. Under these conditions and until factors which influence the rate of heat penetration can be identified and controlled, the processes suggested by the N.C.A. laboratory in *Circular 15-L*, which were listed earlier in this paper, should be used.

PROGRESS IN THE N.C.A. SANITATION PROGRAM

By Edwin S. Doyle, Sanitarian, N.C.A. Western Research Laboratories

The word "sanitary" is derived from the Latin word, "sanitas", meaning health and sanity. Sanity is the possession of a rational mind or common sense. The noun "sanitation" means rendering sanitary or the science of sanitary conditions and use of sanitary measures. The sanitarian is therefore a person especially interested in and versed in sanitary sciences and an advocate of sanitary measures.

Sanitation is not a new consideration for the National Canners Association or the canning industry, but a new emphasis has been placed on sanitation since the N.C.A. Advisory Committees, Administrative Council, and the Board of Directors recognized in 1945 a new public consciousness of cleanliness. Our society is advancing and the public, who are our customers, make practically no distinction between those things of a health nature and those of an esthetic nature. This has been expressed as a consumer demand; and is embodied in the Food, Drug and Cosmetic Act of 1938, Sec. 402 (a) (4), which states in part that a food shall be deemed to be adulterated if it has been prepared, packed, or held under insanitary conditions whereby it may have become contaminated with filth. This section relates to the esthetic conditions under which the food was produced because it does not require that harmful contamination or even harmless contamination had occurred in the product, only that the possibility for its occurrence had existed.

The keynote of these acts and the intent of the legislative bodies is to promote honesty and fair dealing in the interest of the consumer. One should not become so engrossed in the necessities of volume production as to overlook the fact that food should be produced under hygienic conditions and that each individual can he produces will be taken from a grocer's shelf independent of all others and will represent his entire pack and his organization to this consumer. We should look forward to the prospect that the consumer will again become a discriminating buyer.

It is not difficult to comply with the law. Canners are coming to realize that legal requirements are only minimum requirements and that they will want to go far beyond these minimums because of the following factors:

1. Pride in factory and product both by management and employee, in the understanding that they are producing a quality wholesome food for human consumption in a clean plant by clean people.

2. The necessity for maintaining excellent consumer acceptance. Canned foods are now accepted without question as being safe, but they should also be accepted without question as being produced in a commercial kitchen comparable in the housewife's mind with her own kitchen.

3. The desirability of further improving the quality of our products to maintain consumer acceptance. Consumer acceptance is, in actuality, sales, profits, and prosperity.

4. The advantages enjoyed in the prevention of spoilage.

5. The advantages to be gained in competitive advertising. Sanitation is being proclaimed by many industries in national advertising.

6. A greater efficiency of operations which is a by-product of good sanitation.

7. Improved employee welfare which will have an important relationship to the quality and type of employee that can be attracted to the plant and to the efficiency of that employee. This will also have a relation to the attitude of the employee and his respect for his job.

Inasmuch as the current N.C.A. sanitation program is comparatively new, a brief review of the activities since its inception in March, 1945, is in order.

Factory Surveys

The program was inaugurated by the conducting of individual, voluntary, and confidential sanitary surveys. To date, we have completed over 300 surveys and submitted detailed confidential reports of observations and interpretations to the managements. These surveys have been conducted in various canning centers and have included many commodities. They have been a valuable personal service to the canners. We have attempted to be more critical than the enforcement agencies would be in similar situations. In addition, we look for insanitary conditions that relate to employee welfare, quality of product, and efficiency of operations in addition to those that might have a contaminating influence on the product.

We chose to begin the program in this manner because we felt the necessity of learning at first hand more about the problem. We desired to bring the problems and program to the attention of the managements in a practical manner. We wanted the program to be of immediate and practical service to the plants and we wanted to establish a practical basis for projection of a practical program for industry service in sanitation.

These surveys established the broad scope of sanitation in the canning industry and the fact that it is integral with and fundamental to all phases of food preservation, from the choice of the cannery site to the delivery of the product to the housewife in its sealed container. The surveys also established that unsatisfactory conditions resulted in most cases from a lack of recognition, and not neglect, indicating the need of education. They also established the need for a balance between production and sanitation. By this we do not mean to imply that production need suffer because we are convinced that sanitation, properly carried out, is an aid to production and is economically sound. Many of its advantages, however, are indirect and intangible and cannot be entered on the profit and loss statement or balance sheet, but they are real advantages nevertheless.

We have not emphasized the sanitary surveys during 1946, preferring to expend our efforts on the broader coverage of a group educational approach. We have, however, continued to make surveys wherever they have been requested and have extended the service to the territories of the Hawaiian Islands and Alaska. We will reemphasize the sanitary surveys during 1947.

Educational Approach

It is not a function of the National Canners Association to police its member plants or products, but it does appear that our duty lies in promoting improved sanitation in the industry for the advantage of the industry. We have believed that the most beneficial results can only be obtained through education; the education of everyone in the plant from the janitor and the girl on the picking belt to the foreman, superintendent, and even the management, because only by an appreciation and understanding of the principles of sanitation by everyone in the plant can the ultimate ideal of sanitation and its advantages be realized. Our concept of education includes formal schooling, special training sources, and even informal discussion by one person with another in the course of everyday duties; for example, a foreman discussing with a laborer of the cleanup crew the means

and reasons for cleaning a piece of equipment.

With this concept, our entire program has been principally an educational one. In 1945 and 1946 we addressed a number of canners' groups, both local and state-wide in scope, and told them of our program, our hopes and our suggestions and offered them our services. Early in the program it became apparent that there was a lack of trained and qualified sanitarians available to the industry. The N.C.A. therefore requested the University of California to offer a special course in food plant sanitation, and an eight-week course was offered by the School of Public Health, from October 22 to December 15, 1945. Twenty-three men completed the eight weeks and now form a nucleus of trained and experienced food plant sanitarians. Those who attended this class were invited to a conference for the purpose of mutual discussion and exchange of information and experience. The conference was very successful and a great deal of valuable and practical information was developed from the informal discussions.

Through the efforts of the N.C.A. and with the cooperation of state canners associations, short courses in sanitation of two and three days duration were held at Purdue University, Ohio State University, Michigan State College, University of Maryland, Virginia Polytechnic Institute and at the University of Wisconsin. In addition, short courses were given in Illinois, New York and New Jersey.

Beginning in the spring of 1946, two-day conferences were inaugurated by the N.C.A. staff throughout the country. They were organized for, in addition to management, the operating personnel such as the superintendent, the foreman, foreladies, quality control, maintenance and cleaning crews —the people who do the work. The success of these conferences seems to indicate that the plant personnel are anxious for information concerning their responsibilities, and these conferences have in many cases given the man a better concept of his position not heretofore understood.

Training of Sanitarians

To offer further opportunity for training of men specially chosen by management to assume the responsibility of sanitation in their plants, we conducted a two-week special course from December 2 to 14, 1946. The course was conducted by the N.C.A. staff and guest lecturers and covered the fundamentals of sanitation that are pertinent to the food industry, with special reference to general industry problems as indicated from the sanitary surveys. The attendance was limited to 25, as a larger group cannot be reached individually.

The basic principles involved in environmental sanitation were discussed during the course. Instruction included a study of the fundamental principles of sanitary science as applied to specific problems arising from plant operations. It also included the evaluation and application of practical scientific measures for the solution of plant sanitation problems relating to cleaning methods and materials, water, industrial waste disposal, food, insects, rodents, ventilation, plumbing, plant construction and plant equipment, the improvement of plant lighting to aid sanitary maintenance, the standards of sanitary facilities and practical application of those factors involved in industrial hygiene and communicable disease which contribute to economic losses in the plant. The techniques of making a sanitary survey and of evaluating the data were described, and an opportunity was given for practical work.

Those in attendance became acquainted with Federal, State and local legislation concerning sanitation standards and the organization of inspectional services. The interest in this two-week course has been sufficient to obligate us to repeat the course on February 3-15, 1947, and the indications are that interest will necessitate repeating the course again; and the dates March 3-15, 1947, have been tentatively selected.

Published Information

In addition to the above education by direct contact with the individual, we have prepared and distributed various bulletins on sanitation. As an introduction to the Sanitation Program, Sanitation Circular No. 1, entitled "Excerpts from Current Publications and an Outline for a Sanitary Survey" was prepared and mailed to the membership. This circular contained pertinent information indicating the current trend in food industry sanitation, and the demand for it necessitated the mimeographing of 2500 copies.

During 1946, the "Outline for a Sanitary Survey" was revised and made available to the industry. It is very detailed and designed to apply to most canning operations. The mere answering of the questions is quite revealing from a viewpoint that may not have been previously considered and will indicate the wide scope of the application of the sanitary sciences to the food industry. For example, in completing a comprehensive sanitary survey, detailed information should be obtained and careful observations made concerning the adjacent properties and their influence on the plant. The plant grounds and company-owned labor housing should be inspected for sanitary hazards. The building should be observed for construction, ventilation, flooring, paints, wall construction and for state of repair. The general and localized lighting should be carefully observed. The water supply should be inspected for safety and possibilities of contamination occurring. The drainage system should be observed for type, ease of cleaning, maintenance and effectiveness. The waste disposal system, clear to its ultimate disposal, should be checked likewise. Cleanup procedures should be carefully observed for efficiency. Warehousing should be considered for sanitary hazards such as rodent harborages and storage of materials subject to possible contamination or infestation. The entire plant and premises should be carefully inspected for any evidences of insects and rodents, and control methods critically analyzed. The basement and laboratory or cutting room, boiler house, etc., should not be overlooked.

The facilities for the health and comfort of the employees, such as drinking fountains, toilets, washing facilities, and locker rooms must be checked for cleanliness and attention to sanitary practices. The first aid room or facilities should be looked into. The lunchroom or cafeteria should be carefully and thoroughly inspected to disclose any practices that would be a health menace to the employees. The general housekeeping of the plant should be observed.

Everything concerning the handling of the product and the possibility of its contamination must be very carefully observed from receiving through preparation, filling, and closing. The equipment must be observed for ease of cleaning and the fact of whether it is being kept clean. The preparation of sirup, brine, and other ingredients must be carefully observed for possibilities of contamination. Storage of empty containers should be inspected for contamination possibilities and the provisions for the removal of steam and moisture should be given consideration. All of these things require detailed observation and analysis and certain basic knowledge is required if any degree of accuracy and practicability is to be obtained.

Sanitation Circular No. 2, entitled *A Guide to Plant Sanitation* was prepared and distributed in the spring of 1946. This publication provides a very brief resume and review of the general plant problems in a form that can be easily read and understood by the usual plant operating personnel. Two copies were forwarded to each plant and additional copies are available from the N.C.A. laboratories.

Sanitation Manual Drafted

During the eight-week training course given at the University of California, School of Public Health in the fall of 1945, a sanitation manual for food industries was drafted as a class project. The manual entitled "Preliminary Draft of a Sanitation Manual for Food Industries" although limited, incomplete and elementary, represented the best information at the time. The interest in the manual indicated the value of making it available to the industry. The N.C.A. therefore underwrote the printing of the manual and copies may be obtained

at cost from the University Press, University of California, Berkeley. At the present time 4,500 copies have been printed, and the supply is almost exhausted. Sections of this manual have been reprinted in the *Canning Trade*. Work is in progress on a more complete manual but considerable time will be required to complete it.

The use of visual aid materials was of great value at the two-day sanitation conferences and the two-week training course, and it is planned during 1947 to develop more of this type of material for the industry's use.

The first two issues of a sanitation News Letter entitled "The Conveyor," have been distributed to permit exchange of ideas and distribution of new information between the plant sanitarians. We have hopes that this will prove valuable as a means of conveying information concerning sanitation.

The Future of the Sanitation Program

There is a need for a great deal of research on various sanitation problems, and we will attempt to stimulate research. Much of the research work will have to be done by the sanitarians working in the canneries if we are to have practical results. The N.C.A. will conduct research also, and has done so on total plant chlorination. A very valuable meeting was held in Chicago in December concerning the research work that had been done on chlorination and practical experiences with its use in several canneries.

We would be remiss in our duties if we merely promoted sanitation and did not offer assistance on special problems of the individual members. Therefore the laboratories of the N.C.A. are available for consultation concerning problems relating to sanitation and as a clearinghouse of information. We are very much aware of the complexities of plant sanitation and, although many problems are as yet without solutions, the solutions will come with time and we will make available the best information as it develops.

It is not possible for us to give detailed coverage to each plant without having a staff entirely disproportionate to all other laboratory activities. It is the responsibility of each plant to keep its own house in order; and, to accomplish this, it is advisable to place the sanitation responsibility of the plant in the hands of some qualified individual. The details of sanitation are too many and the scope too wide for it to be successfully handled by anyone who can only give it passing attention. The management and other top production men have no time to devote to it and shouldn't be required to give it their detailed attention—their attention should be devoted to production and they should have the assistance of some one with a specialized interest in sanitation. This person might be a full-time sanitarian, or he might supervise several plants. However, with a part-time sanitarian, an effort should be made to avoid the dangers of divided interest, divided supervision, and an insufficient allotment of time. The sanitarian should be tactful, diplomatic, have initiative, imagination, perseverance, and above all, have the ability to use common sense. Attendance at the sanitation schools and conferences offered by the N.C.A. is recommended for his information and guidance.

No manager should delude himself that his problems are immediately solved upon the appointment of a sanitarian or the placing of the title of sanitarian on a person inexperienced and uninterested in sanitation. A mere window dressing will be of no value.

When management selects a sanitarian and properly trains him he should have every opportunity to work with men of similar interests from other plants, for there are no secrets where sanitation is concerned.

Sanitation is a long term program, and we urge the establishment of an adequate, projected program in every plant. It is very likely that many corrections will have to be deferred, but their existence should be recognized and plans formulated toward their correction. Society will continue to advance and we must keep pace.

During 1947, the program on sanitation will include the following service factors:

1. Train cannery personnel selected by management to supervise over-all sanitation programs by means of training courses.

2. Make individual plant surveys on requests.

3. Provide consultation service to the industry on problems relating to operation and organization of plant sanitation programs; reconstruction, etc.

4. Stimulate research on cleaning materials, and cleaning procedures, insect control, paints, etc.

5. Prepare visual aid material in addition to circulars, bulletins, etc., covering up-to-date material and the results of studies by the industry sanitarians and the results of our research work.

6. Publish at frequent intervals a news letter, *The Conveyor*, on food plant sanitation for the plant sanitarians.

7. Continue to compile material for a revision of the manual on food plant sanitation.

It is a pleasure to report to the Convention that the Sanitation Program of the National Canners Association is meeting with exceptional interest and acceptance, and that the progress has been most gratifying. With the continued cooperation of canners, we will endeavor to aid, to the best of our ability, in the sanitary, efficient production of quality canned products.

CHLORINATION OF CANNERY WATER SUPPLY

By E. C. Ritchell, Minnesota Valley Canning Company

The introduction into canning and frozen food plant water supplies of sufficient quantities of chlorine to achieve break-point chlorination was reported by Hall and Blundell (1) in 1946. While not previously utilized for this specific application, the varied advantages of break-point chlorination have for several years been successfully utilized for municipal and other industrial water supplies. The method involves the addition of chlorine in sufficient quantities to produce and maintain free available chlorine residuals to the exclusion or near exclusion of chloramine residuals. This process differs from marginal chlorination where chloramine residuals only are given consideration. In general, it is achieved through the addition of larger, though controlled, quantities of chlorine over those required in the marginal chlorination procedure. The free chlorine residuals thus achieved are far more effective than chloramine residuals for the control of bacterial growth. Break-point chlorination is also a recognized means for control of slime growths and for reduction of tastes, odors and color in water supplies.

On the basis of initial results obtained at two plants, it was reported in 1946 that in-plant chlorination beyond break-point levels during operating periods resulted in a considerable betterment in general sanitary conditions through prevention of slime growths and the control of off-odors commonly encountered at inaccessible points about plant buildings and equipment. The advantages obtained through the use of an increased chlorine concentration during clean-up periods were also reported. These results were obtained without difficulties from off-flavors in the several products packed.

In advance of the 1946 packing season, several additional in-plant chlorination installations were made. These were geographically widespread and were made in plants handling a considerable variety of fruits and vegetables. For a few products, notably peas and corn, plants having widely varying construction and product handling methods were represented. These installations afforded an opportunity for more complete evaluation of the method involving the various factors discussed below.

During December of 1946, a conference was held by representatives of various processors, the National Canners Association Laboratories, and industry groups experienced in the method. Its purpose was an exchange of information leading toward the establishment of a number of general conclusions representing a common viewpoint among those present. It is the purpose of the present paper to present and, where necessary, to enlarge upon these conclusions.

Slime and Odor Control

The occurrence of slime on equipment surfaces provides one of the most serious obstacles to the maintenance of a high level of sanitation control. Slime development occurs with varying degrees of rapidity and, in some plants, appears to offer no serious problem. However, in many plants growth is widespread and rapid, and removal is time-consuming, even where carried out nightly and with the assistance of modern sanitation aids. This applies particularly to bacterial slimes rather than accumulations of organic material derived from the product. Removal of the latter is largely a mechanical procedure.

One of the most significant advantages of in-plant chlorination lies in the ability to prevent or greatly reduce slime. Optimum results are obtained on equipment which is continuously sprayed with chlorinated water. Equipment such as conveyor and inspection belts are effectively treated by this means through the installation of simple spray pipes. In some cases, it is advisable to spray the underside of the belt as well as the surface in contact with the product. Several possible methods of application to belts have been used ranging from sprays installed over the belt at the feed end to underside installations at either belt end. In some instances where relatively moisture-free inspection belt surfaces are required, squeegee blades have been placed within a few inches following the point of water application. While these conditions represent wide variations in contact time, excellent results have been reported where sufficient quantities of water were used. Variable results have been obtained on equipment such as bucket elevators which have irregular surfaces. In such instances, greater care must be taken in making spray installations.

In addition to types of moving equipment, it is frequently possible to install sprays on fixed equipment, although, in many cases, a limitation arises due to proximity of employee working stations. Where continuous spraying is not practicable, assistance in slime control may be obtained by frequent applications of chlorinated water.

The degree of slime control obtained on immersed surfaces such as tank, flume and piping interiors will depend largely upon the extent to which the free chlorine residual has been reduced through contact with organic matter. For example, slime control may be incomplete on immersed surfaces where extensive hydraulic handling of the product and frequent recovery and reuse of water are practiced. In such instances, the chlorine residuals carried will revert to the chloramine type which will, however, assist in some degree toward slime prevention.

One of the most important considerations involved in the method lies in the increase of chlorine concentrations during clean-up periods to a point well above those levels used during packing operations. Experience has shown that this procedure facilitates the removal of slime which has accumulated during the daily operation. This means is most effective when used in conjunction with a well co-ordinated sanitation program, since chlorinated water is not effective for the removal of heavy slime deposits such as accumulate after periods of several days without proper attention.

The important aspect of slime prevention and removal constitutes, in the opinion of processors experienced with the method, a means for reduction of clean-up time. Where slime is a problem, this will permit appreciably longer hours of operation.

The considerations stated above apply in a general way to odor control. Continuous spraying will accomplish prevention or considerable reduction and frequent applications to surfaces which cannot be continuously sprayed will also result in reduction. This applies, of course, to odors which are the result of bacterial or similar decomposition of vegetable material. Such conditions frequently occur at locations such as floor drains, not in contact with the product and thus more likely to be neglected. The use of chlorinated water on preparation equipment may, through lack of contact, have no direct effect on such sources of odor. Abundant use of chlorinated water will, through release of free chlorine into the plant atmosphere, tend to neutralize such odors while not attacking the source. Plant odors not necessarily unpleasant, but characteristic of the raw material or the processing thereof, are likewise neutralized in this manner. In most instances, there will result a slight chlorinous odor which is generally considered to be indicative of cleanliness and is thus acceptable, if not preferred by employees.

Chlorine Residuals

It is not possible to make specific recommendations regarding the free chlorine residuals to be used. The three principal factors to be considered in establishing the proper residual are: (1) possible development of off-flavors in the product, (2) the control of off-flavors and odors in the water, and (3) the chlorine requirements for sanitary maintenance. Because products vary in susceptibility to damage and because of differences in plant construction and type of water supply, individual determinations must be made for each plant and for each product within the plant. Tests must be carried out using plant produce and plant chlorinated water. However, for purposes of orientation, it may be stated that applied concentrations ranging from 2 to 5 parts per million have been used during operating periods, with concentrations as high as 50 parts per million during clean-up.

Off-flavors in the Product

Although a preponderance of experience indicates that levels satisfactory for sanitary control may be maintained without difficulty from off-flavors, sufficient exceptions have been noted to warrant the preparation of experimental packs before use of the method in actual operations. Where off-flavors are found, attention must be given to the several types of contact between product and chlorine in the production scheme. Zuch and Somers (2) carried out tests of this type which will serve to illustrate the type required. These packs included a variety of fruits and vegetables and employed standard commercial canning practice with variations in chlorine concentration over the broad range of 2 to 50 parts per million. Observations made on canned samples included flavor, color, ascorbic acid, pH, Brix, vacuum, and drained weight. Of these factors, only flavor was found to be of significance. Chlorine contacts were assumed to be of three types provided: (1) by the wash water, (2) by the brine or syrup filling medium, and (3) by heated water or solution as in blanching, scalding or lye peeling where such was required in the process. Three types of test packs were made involving the use of chlorinated water in all contacts, in wash water and heated water or solution only, and in wash water only. Of the products tested, peaches were found to be most susceptible to off-flavors, these resulting from the use for syrup preparation of water which was chlorinated to 5 parts per million. This finding corresponds with that of one canner in commercial packing. In general, the use of chlorinated water for washing, blanching, scalding or lye peeling is without effect except at the higher concentrations. Since syrups prepared from chlorinated water also produced noticeable effects on other products, it is recommended that chlorinated water not be used for this purpose without careful test.

Two widely processed products not included in the above experimental series were peas and corn, which, under conditions prevailing in several plants, have been found to be unaffected. The foregoing type of test should, nevertheless, be carried out.

Since many installations provide for chlorination of the total water supply,

it is necessary to consider carefully the subject of its acceptability for drinking purposes. This is emphasized by the fact that conflicting reports have been made by the various processors. Common off-flavors and odors associated with chlorine are of two general types—those due to chloramines and possibly other partially oxidized matter encountered with marginal chlorination, and those due to free chlorine. Usually the former type is considered the more objectionable. It is accepted that optimum results will be obtained at break-point levels since concentrations of chloramines are at a low level. However, when operating well beyond the break-point, the chlorinous flavors and odors may become objectionable. Several canners report strong initial objections from employees, with acceptance developing after short intervals.

Since a time factor is involved, the attainment of true break-point conditions is sometimes not possible in plants making chlorine application immediately before use of the water. In general, a break-point is obtained when the free chlorine residual is approximately 80 per cent of the total residual including chloramines. Where this is not possible, it may be necessary to use an un-chlorinated or less heavily treated drinking supply. This may also be necessary where sanitation demands are such as to require residuals sufficiently far beyond the break-point to result in an unpalatable chlorinous condition. De-chlorination of a portion of the supply would offer an alternative in the latter case.

It will be apparent from the discussion covering the aspects of slime control that these residuals must be determined by experience and will depend, in general, upon the quantity of free chlorine available for interaction with organic matter and upon the contact time. A given residual will produce variable results throughout the plant since wide differences in contact with chlorinated water are inescapable. Where entirely satisfactory results are not obtained at the first trial, the application of higher residuals will usually be the first corrective measure applied. While this may result in some improvement, it is perhaps more reasonable to expect that improvements may be obtained through greater or more careful application of the water to the troublesome surfaces. Where the latter means is not feasible, it will be necessary to resort to hand methods of cleaning. With this in mind, it may be understood that results obtained will vary considerably with plant construction. It is of the utmost importance to recognize, however, that even with good plant lay-out and careful application, the use of in-plant chlorination will not render the plant self-cleaning. No relaxation of effort toward attaining and properly co-ordinating a suitable sanitation force should be permitted. This applies equally during operating time and during the night clean-up.

Corrosion of Equipment

Observations made by users of the method disclose no equipment corrosion problems attributable to chlorinated water. While this experience is limited in time, the relatively greater period of use in other fields appears to justify this view, at least insofar as residuals carried during operation are concerned. In the past, many instances of can corrosion during or following immersion in chlorinated cooling water have been recorded. Although corrosion tests have been performed with negative results on containers immersed in water containing as high as 50 parts per million of chlorine, it would be well to consider this factor, particularly where so-called "corrosive" waters are encountered (3). In some instances, the addition of relatively small amounts of chlorine to such waters has resulted in rusting of tinplate.

The relatively higher chlorine residuals utilized during clean-up periods, while corrosive in character, are unlikely to cause difficulties because of short exposure time. However, care should be exercised in the use of this water for cooling of cans. In addition, its use as boiler feed water would also appear to be questionable. Since definite information on this subject does not appear to be available, it would seem wise to avoid its use. Where this is not possible, a de-chlorination system or a source of un-chlorinated water, possibly desirable as well for drinking and brine or syrup supply, may be indicated. In all probability, no difficulty will be encountered where boilers are equipped with deaerating or open tank type preheaters. The foregoing may be considered an unnecessary precaution and may indeed be such where very small quantities of boiler feed water are required during clean-up time. It appears justified, at this time, to assert that concentrations employed during packing operations will have no effect on boilers.

Reduction in Bacterial Population

Considerable data were obtained by the cooperating agencies in the course of investigating the extent of reductions in bacterial counts accomplished by in-plant chlorination. Of the several factors investigated, none gave less uniform results. Principally involved in these studies were determinations of mesophilic counts, and to a lesser extent, thermophilic counts, on various equipment surfacts, in plant waters used for handling of the product, and on samples of the product selected at various points throughout the operation. In general, the average bacterial counts were lower when chlorinated water was used. However, consistently lower total counts were not obtained. Results obtainable again depend upon the amount of chlorine available for contact with bacteria or available for elimination of organic accumulation upon which bacterial growth may flourish. It is apparent that the following factors will influence this relationship, and in consequence the over-all reduction obtained:

1. The initial contamination of the product, which acts as an inoculant for the plant.

2. The rate of product movement through the plant, which influences the incoming concentration of bacteria and the removal of free chlorine residuals through contact with organic material.

3. The nature of the contact with chlorinated water, involving the quantity of water used and its method of application, that is, whether in flumes, through sprays, or by immersion.

4. The time of contact with free chlorine, important because lethality, even with this agent, is not instantaneous.

5. The chlorine concentration, upon which lethality is dependent. However, chlorine also combines with the organic matter of the product, thereby reducing the amount of chlorine effective for destruction of bacteria.

6. The air and water temperatures, which influence the rate of multiplication of bacteria.

7. The re-use of water, which due to repeated contact with the product may render the maintenance of free chlorine residuals an impossibility.

8. The general sanitation level, which influences the quantities of organic material present.

9. The possibility of recontamination, which may be encountered where the product passes through equipment not in contact with chlorinated water.

It would appear that maximum results would be obtained where considerable fresh water and extensive hydraulic handling of the product were used. This may preclude the use of extensive water recovery and re-use, since efforts made toward the re-chlorination of recovered water have not been encouraging. Maximum results will be obtained where large quantities of fresh water are available and a high degree of sanitary maintenance is exercised.

It is unlikely that a reduction in spoilage of canned products caused by thermophilic flat sour organisms will be obtained by direct destruction of these organisms. The ineffectiveness of chlorine on their spore forms has long been recognized, although viable organisms may be destroyed. Conceivably, some betterment may be obtained in those instances where chlorine has resulted in the removal of a slime condition which formed a breeding point. Unfortunately, chlorination has little direct effect on blanchers and on other equipment maintained at high temperatures.

While it is not within the scope of this paper to deal with the construction and operation of gas chlorinating equipment, one factor, the principle of automatic control, is worth mention. The method applicable to in-plant chlorination installations is not a direct control based on automatic measurements of the residual, but rather a means whereby addition of chlorine is made in proportion to water flow. In operation the proper setting on either manual or automatically operated machines is achieved by chemical determination such as the Laux Test using ortho-tolidine. With a manual machine, this setting will maintain the desired residual only where the water flow is constant. At lesser flows possibly harmful residuals will be obtained, while at greater flows the residuals may be insufficient to produce desired results. An automatic machine will compensate for flow differences, utilizing as a means of adjustment on the chlorinator the varying pressure differential across an orifice plate or venturi tube installed in the plant supply line. While it may appear on first analysis that water consumption at a given plant is reasonably constant, this is seldom the case. Accordingly, it is strongly recommended that automatic chlorination equipment be used.

Of the commercial in-plant chlorination installations reported to be in use virtually all utilized chlorine gas rather than other forms. This selection of method appears justified since it is standard for the treatment of larger water supplies. In some instances involving relatively low demands, other sources of chlorine may be considered. The choice may be based upon economic balance considering water volume, hours of operation, chlorine costs, equipment costs, and cost of preparation of chlorine solutions, if such are considered. The possible effect of accompanying inorganic salts, for example, those of calcium, must be considered.

Precautions

In addition to those previously stated precautions dealing with harmful effects on the product and on the water supply, the following must be carefully observed:

It is essential that a competent person maintain a system of constant checks on the chlorine residuals prevailing at various points in the plant. As a minimum, this should include samples taken from the water supply line before use in the plant and at the most remote point in the distributing system. Particular care must be taken to avoid the use during packing operations of the high residuals desirable for clean-up. Periodic checks for off-flavors and odors in the water supply and the final product should be made. This will prevent excessive losses due to the remote possibility of chance contaminations in the water or raw material supply. As an example, there should be mentioned a case where a quantity of a phenolic substance was introduced into a municipally chlorinated cannery supply with resultant loss of a substantial pack. Difficulties of this type may arise as well from the use of plant materials containing phenols.

The hazards associated with chlorine are well recognized. Accordingly, it is essential to observe standard industrial safety practice in making equipment installations and in their operation. These include the availability of approved gas masks, separate housing or venting of rooms containing equipment, and protection of chlorine cylinders from excessive heat.

Restated in summary form the following conclusions represent the experience of those persons attending the recent in-plant chlorination conference:

1. Slime and odors may be prevented, or greatly reduced, on all equipment or surfaces which are continuously sprayed with chlorinated water. Frequent application of chlorinated water during the packing period to equipment and surfaces not constantly bathed with chlorinated water will assist in control. After slime has developed, removal by the application of chlorinated water is difficult.

2. Experience has shown that increasing the chlorine concentration during clean-up over those levels used during packing operations gives better removal and control of slime.

3. It was the opinion of the representatives from canning companies present at the meeting that the use of chlorinated water permits longer hours of operation by reducing the time of clean-up.

4. No chlorine residuals were recommended for any particular product since this is essentially an individual plant problem and the requirements may vary from day to day. In order to insure maximum benefits from chlorination, it should be carried beyond the break-point.

5. Because of various products and packing conditions, it is recommended that each product in each plant be studied separately to determine the possibility of off-flavors or other adverse effects under those particular conditions.

6. Until further work can be done, it is recommended as a result of off-flavor produced during commercial packing of peaches, that water chlorinated in the cannery should not be used in the making of syrups. Its use in brine is optional. With the exceptions noted, a wide variety of products has been packed with no adverse effects on color or flavor.

7. It was reported by some canners that their employees did not object to drinking chlorinated water. However, it was reported by other canners that their employees did object. This difference is probably related to the quality of water used and chlorine residuals carried.

8. No corrosion in equipment was reported which was attributed to chlorinated water. It was the opinion of those present that concentrations normally used during packing operations would have no injurious effect on boilers. No decision was reached concerning boiler corrosion when higher concentrations of chlorine are used in water during clean-up operations.

9. There is, in general, a tendency for total bacterial counts to be reduced by chlorination. The degree of reduction in total counts depends upon a number of factors, among them are: (1) initial contamination of the product, (2) the amount of product passing through the line, (3) the nature of the contact (amount of water used, method of application, flumes, sprays, immersion, etc.), (4) time of contact, (5) chlorine concentration, (6) the reuse of water, (7) air and water temperature, (8) general sanitation. Recontamination may occur if the product passes over equipment not receiving chlorine application.

10. There was no apparent effect in controlling thermophilic flat sour spoilage organisms in plants where tests were made.

11. To insure adequate control, it is essential to use automatic gas dispensing equipment for chlorinated water. Practically all the commercial experience to date has been with the use of chlorine gas rather than other sources of chlorine.

Precautions Summarized

1. Prudence dictates a cautious approach to the chlorination of the general plant water supply, since it is a new field. Before chlorinating, it is advisable first to determine the maximum residuals of free chlorine which can be carried in the water without objectionable odors or flavors, and second, what effect, if any, varying residuals of free chlorine would have on the product.

2. It is imperative to avoid the use of phenols or related compounds in a canning plant using chlorinated water.

3. Chlorine residual test kits should be provided and periodic checks made.

4. Readjustment of chlorine concentration should be made before each day's run.

5. Standard industrial safety precautions must be observed in the use of chlorine gas.

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DESIGN OF SANITARY CANNING EQUIPMENT

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The history of the growth of the canning industry is the history of the development of automatic machinery. It has been a long road from the hand operated cannery to the present bewildering array of automatic and special purpose machinery which performs a multitude of tasks in every part of the canning operation.

The expansion in the use of machinery resulted in great increases in the productiveness of a given amount of floor space for each hour of production and was paralleled by increases in the production hours per day and the production days per year. The end of this progress is not even in sight. The attack by inventors, scientists and engineers on problems of design by higher speed, and by more economical and more efficient canning machinery is greater than ever in the history of the industry. There are more companies manufacturing canning machinery and more individuals in each company concerned with finding mechanical ways of doing hard jobs than ever before. No problem seems too tough to tackle. Even the seemingly insurmountable problems of field harvesting of fruit and quality grading at the canning tables, hitherto seemingly the inviolable field of hand operation, are considered fit subjects for investigation by the design engineers.

Up to the present time relatively little attention has been given by design engineers to the broad aspects of machinery sanitation. True, wherever possible, machines have been made demountable or accessible for cleaning on an "end of the shift basis." Fillers particularly and also some of the equipment for handling finished or semifinished material has been designed so that cleaning at the end of the day is at least possible and in some cases easy. However, too little attention has been given to the general problem of designing machinery so that it will accumulate a minimum amount of rubbish and infection.

This is not solely the responsibility of the machine manufacturer, but blame must be shared in some part by the canners who buy and use it. These have not always been aware of any economic advantage in better designed and constructed, and therefore more expensive, equipment. Economic considerations will always be a determining factor in the purchase of canning equipment. In some cases at least there must be an obvious relationship between cost of equipment and cost of clean-up of the equipment.

Consideration of design of machinery for proper sanitation should not be considered to be limited to those larger companies specializing in the construction and sale of large or complex machinery. Installation of machine construction and repair shops in food producing plants has been widespread, and has resulted in construction on the premises of substantial amounts of food handling machinery. Probably in the future even more of simpler types of food machines will be constructed by operating concerns and this will require consideration of correct principles of sanitary design by every shop engineer, chief mechanic or other person responsible for such design and construction.

The story of machine sanitation in the frozen food industries is in general similar to that in the canning industry. Since the handling and preparation procedures are approximately similar, up to the step of packaging and processing the packaged food, specific features of machine sanitation may bear alike on both systems of food preservation, although, the relative importance of different factors may vary widely.

Types of Contamination

As far as these industries are concerned, sanitation in relation to machine design involves consideration of four general factors of possible product contamination which may be listed as follows:

1. Contamination by spoilage bacteria. By this is meant all organisms which by their action subsequent to final processing, may cause deteriorative changes in the product, whether of a toxic nature or not. The types of organisms grouped under this heading are entirely different in the canning and frozen food industries. For the canning industry it should include not only thermophiles which may not be destroyed by extreme processes but also organisms of lower heat resistance which may, if present in sufficient numbers, survive the common commercial process.

2. Contamination by non-spoilage bacteria. This category is intended to include organisms which cannot cause spoilage in the product after packing but which indicate, by their numbers, that improper packing procedures have been used which have permitted undue increase in their numbers.

The high counts of mold, which sometimes occur in tomato products are not considered to be in this category since they may not be significantly related to machine sanitation.

3. Contamination by foreign biological materials. Foreign biological materials are comprised of insects and their parts or feces, rodents and their parts or feces, and foreign plant materials. The foreign plant materials are infrequently a cause for concern in plant sanitation since their source is usually the food product itself.

4. Contamination by chemical or physical materials not biological in origin includes all other sources of contamination.

Obviously any such broad classification of sources of contamination has applicability beyond the limits of machine sanitation. It is, however, intended to consider them here only in their relationship to this problem.

The significance of contamination by spoilage bacteria must be different in the canning industry than in the frozen food industry. Inclusion of excessive numbers of spoilage bacteria, in food products to be canned, carries such a threat of spoilage and economic loss that the industry might be considered safely left to police itself on this point. Self policing, however, can only relate to clean-up procedures. If equipment design permits rapid growth of these classes of organisms, between reasonably spaced clean-up periods, then the equipment design is at fault and must be corrected. Much needs yet to be done in equipment design to minimize this type of contamination.

It is proper to voice the inquiry so often heard, as to why it is necessary to minimize contamination of food products by non-spoilage bacterial types. Perhaps the most significant reply is that increases in bacterial count can never occur without some product changes. Somewhere the border line exists between a sound product and one incipiently spoiled.

Naturally it is in this border zone that controversy between the packer and public agency so often arises. However, undue increases in non-spoilage bacterial count are useful indices of general cleanliness. Cleanliness and high bacterial counts are not compatible. Also, increases in count can occur at times and temperatures which are significant for vitamin destruction and perhaps some kind of rough correlation may occasionally exist.

In frozen foods, high counts of bacteria may indicate potential high rates of product degradation with certain methods of thawing.

The machine designer's interest in biological contamination lies in removal of such contamination already in the product and in preventing such contamination of the product during operation of the machinery. He is concerned, in cleaners and washers, with insects and rodents, and in the provision of tight covers on other machinery to keep them out.

Removal of existing biological contamination from the product involves functional operation of cleaners, washers, shakers, etc., and is not, therefore, a concern from the point of view of this discussion. However, insurance against biological contamination acquired during operation of equipment does involve mechanical features of all equipment of interest to the sani-

tarian. Perhaps the simplest example might be the operation of the shaker feed of a peach slicer. This unit produces considerable vibration, and if it is mounted insecurely under a beam serving as a rat run, so as to cause the beam to vibrate, contamination of product may occur. Keeping rodents out of the plant or reducing the number by general plant sanitation will also keep them out of machines. However, covers or guards should be so placed as to keep filth from dropping from overhead. Where tight covers are impossible by reason of the nature of the machine's functions, permanent or removable hoods offer some protection against falling filth and the ingress of flying insects. This can, of course, only be supplementary to adequate plant screening.

Chemical or physical contamination may come from the equipment itself, and call for the collaboration of the chemist and metallurgist for its prevention. Or it may come from outside in a manner similar to the biological contamination just described, and thus remain in the province of the sanitarian, and be the responsibility of the design engineer.

Sanitation of Machinery

To attempt any complete or detailed discussion of problems of sanitation of all or any large number of the multitude of machines used in the food industries would be an Herculean assignment for any individual. Each machine carries its own peculiar problems and the solutions of these are sometimes neither obvious, simple, nor necessarily applicable to other machines. Many kinds of automatic machinery are highly intricate mechanisms utilizing the greatest mechanical inventiveness and design ingenuity. It is not clear how some of these may retain their present functional efficiency and still meet the ideal of sanitary requirements. However, it is apparent that the machine designer must now give more thought than in the past to these sanitary requirements.

Even the best designed machine may, however, become a dirt and bacteria trap if improperly installed. It is as much the responsibility of the operator who installs the equipment to see that sanitary requirements are considered as it is that of the manufacturer to produce a machine which can be cleaned and remain clean.

One thing common to all machinery in a food plant is the fact that it must be supported on some kind of foundation, stand or bracket on the floors, walls, pillars or beams of the building. Most of such equipment is supported by some kind of stand resting on the floor. The legs of these stands furnish a veritable forest of obstacles to the clean-up crew. Material economies in clean-up costs can be achieved by careful consideration of such machine mountings.

Machines are getting larger and heavier all the time. Frequently the larger pieces of equipment are furnished with solid cast bases. Such machines should be mounted on solid foundations which should not permit entry of water, insects, rodents, or food spillage. The machine should be bonded securely to the foundation. And of course, the foundation of the machine itself should be also tight enough to prevent entry and accumulation not only of refuse, but also of excessive oil or grease leakage.

The commonest floor frame mountings for machines are constructed of wood or angle iron. Wood is the worst possible type of floor mounting for machine operation where water, food juices or food particles are concerned. Not only is a wood frame impossible to keep clean, but because of its relative lack of strength a larger floor area must be covered by the supports and the supports must be closer together. There may be a place in the canning warehouse or the freezing and cold storage rooms for well surfaced, well painted wood structures, but certainly wood is out of place on the preparation and packing floors.

Angle iron is not much better. While it is initially impervious to water the hot rolled surface makes effective paint application difficult. The flat surfaces hold drip and condensate, and corrosion is rapid, resulting in a scaly surface. Together with the flat elements and necessary corners, which collect all kinds of refuse, including flora and fauna, such structures offer an expensive and sometimes unsolvable riddle to the clean-up crew. The main attraction of angle iron is ease of construction. There are few difficulties of design. A hack saw, cutting torch and electrical welder are the simple tools required, and little skilled labor is required. All of these factors represent low initial cost. Almost anyone can build machine stands of angle iron and almost everyone does.

Construction of machine stands from standard pipe, steel tubing and rods offers many real advantages. Stronger, lighter construction is possible. With increased strength of the structure, fewer points need touch the floor. There are no flat surfaces. Even horizontal members offer little residing place for refuse. There are no corners. Water runs off and corrosion is minimized so that paint jobs last longer. Contacts between structural elements and machines are welded, and can be finished smooth. Maintenance and clean-up cost less. However, tubular construction costs more because more skill is required for construction. If full advantage is to be taken of strength of materials, careful engineering design is required. In the end, however, the overall cost should be less because of savings in daily clean up, seasonal maintenance and decrease in depreciation.

Preferably the ends of tubular structures should all be closed permanently. However, it doesn't do much good to seal all openings and then drill a hole for a bolt to hold the machine in place on the stand. It would be better to weld on small brackets for fastening bolts without perforating tubular structural members.

The same general considerations hold for wall bracket mountings and suspension supports. It is unfortunate that more canneries are not constructed to permit vertical suspension supports.

Machine Design and Construction

Automatic food preparation machinery offers one of the most difficult problems to face the sanitarian. Included in this class are units for peeling, coring, pitting, cutting, dicing, slicing, shredding and juicing. All such equipment is carefully designed from a functional point of view and because of the intricacy of many of the functions, sacrifices of sanitation have necessarily resulted. It is very difficult to suggest sanitary improvements of group significance. Naturally every effort should be made to remove solid refuse continuously. Some of these machines can be continuously sprayed with water. Where total plant chlorination is used, contamination of such machines may be reduced if the solid matter is removed continuously. Solid organic matter in residence in a machine being sprayed with chlorinated water can use up the available chlorine so fast that it may be completely ineffective to minimize bacterial build-up.

Automatic machines are costly and not always constructed entirely of corrosion-resistant materials. To determine the advisability of using chlorinated water on such machines, due consideration should be given to possible increases in depreciation rates. Constant washing in water containing a high percentage of available chlorine might result in serious increases in corrosion. Studies are needed to show the desired balance between cost of clean-up and cost of maintenance, and probably these can only be carried out satisfactorily on a plant scale.

Antifriction bearings should be equipped with adequate oil seals and be force-feed lubricated. Entrance of water and organic material into a bearing warmed by friction may result in thermophilic spore formation. Contamination from an unprotected bearing might be subsequently returned to the product by periodic lubrication. Continuous forced-feed lubrication would prevent such occurrence by keeping water and organic matter out of the bearing. Of course, adequate drainage of excess lubricant is required to prevent product contamination from this source.

Equipment in this class would seem to be little subject to contamination with foreign biological materials during use except from overhead beams or the like. Consideration should always be given to enclosing the equipment with proper covers to reduce the possibilities of such contamination.

The general design of covers and guards should be such as to offer minimum product hold up. It goes without saying that accessibility for cleaning is imperative. Sloppy design of machine covers can offer more sources of contamination than they prevent.

Cleaning Methods

Probably with automatic machinery more can be accomplished by a study of proper and adequate clean-up methods than by considerations of redesign which are necessarily slow and costly. A study of individual types, particularly where group installations are involved may reveal that special cleaning tools and brushes will improve and speed up the job. However, one of the most expensive and rarest commodities today is elbow grease, and substitutes are more than welcome.

Too little attention has been given to the possibilities of high pressure water for clean-up purposes. By high pressure is meant 500-600 pounds, not the usual so-called high pressure of 100-200 pounds. The effectiveness of the mechanical action of relatively low capacity at high pressure in removing particles and scums from surfaces should be obvious. A Niagara could pour over such surfaces at low pressure with no effect at all, but when the force of the stream approaches the adhesive forces of the particle film it must move. Here pressure, velocity and kinetic energy of the water substitute for elbow grease. Low velocity water will dissolve sugar and other solubles but it is slow and inefficient for other cleaning purposes.

Such streams have some hazards and must be under complete control at all times and must also be used with judgment. Heavy, solid, high pressure streams can blow out a light bulb or a window. However, nozzles are available, giving trigger control to the stream and also control of volume and type of spray. Such cleaning means combined with proper temperatures, detergents and disinfectants should not only aid in effectiveness of clean-up of machinery of the type under discussion and others as well but should decrease the cost of such clean up.

Unit Process Machinery

Another class of food equipment might be called unit process machinery. Included in this group are, blanchers, scalders, washers, blenders, pasteurizers, coolers, flotation separators, desilkers, pulpers, finishers and similar equipment. Sanitation of such equipment is of particular interest since its surfaces are in continuous direct contact with food juices or extractives, frequently in a warm or hot condition, particularly favorable for growth of the most undesirable forms of bacteria. Design of such equipment must take into consideration not only the possibility of really effective periodic cleaning, but also the avoidance of areas of stagnation, incomplete drainage, local dilutions and similar problems.

In such equipment, dead or stagnant areas are particularly to be avoided. Such areas, which permit the food or its extractives to remain for extended times may allow the growth of enormous populations which thoroughly seed the remainder of the product flowing through the machine.

Materials of construction should be non-porous, non-corrosive and smooth. Castings particularly should be free of blow-holes or other imperfections and be well cleaned up. Contact areas between sheets should be tight and free from blind openings.

All blind pipe inlets should be plugged so that the inside plug ends are flush with the working surface. If direct steam is applied by pipe line to the product, such lines must be so equipped and operated that no product will be sucked back into the line where it may remain in residence overlong. Check valve systems can be installed in direct steam input lines so that vacuum cannot be created in these lines when steam is shut off. This is not an inconsequential suggestion. Numerous instances are reported where suck-back into stream lines has led to serious contamination of product.

Many machines in the class under discussion contain shafts, stuffing boxes and bearings. The comments made regarding such parts in connection with automatic machinery are equally applicable here.

Most machines which retain a bulk of fluid or semifluid products have drains for flushing out during clean-up in addition to the product outlet used during production. Such drain outlets should either be closed with a plug which is flush with the inner working surface, or if a pipe nipple and a valve must be used the nipple should be as short as possible and the valves set as close as possible to the main body of the machine. Long drain nipples should be avoided as furnishing an undesirable dead area.

Flow of product through equipment should be streamlined. Sharp square corners which tend to decrease the local rate of flow should be avoided wherever possible. Where water or brine is used as the treating fluid for solid food pieces, tanks should avoid areas of such low velocity flow that solid particles of food or waste can settle out and accumulate. In such units the amount of fluid in residence in the equipment should be as small as possible and the rate of make-up should be sufficient to enable maintenance of low bacterial counts.

Steam an Inefficient Cleanser

In cleaning equipment of this class a steam hose is often used variously to dry surfaces, remove refuse, remove free water, sterilize surfaces and cut grease. In all of these applications steam has decidedly limited value. Few people realize that a flow of steam from a hose injects so much air that it condenses very rapidly only a short distance from the nozzle tip; therefore, it has a very low rate as a sterilizing agent.

Only by condensation can steam carry away solid particles by flotation. It cannot compete with high velocity water containing proper types of detergents and disinfectants for grease and refuse removal, and for sterilization. Fluid water is required to float away a solid material. Perhaps the only legitimate use of steam in plant clean-up is to remove large deposits of water from surfaces and from the interior of intricate mechanisms. Because of its low temperature, the ability of steam to warm surfaces and dry them by heat is very limited. Of course these comments do not apply where steam can be confined and used under pressure.

Water in raw product washers should not be recirculated. If recirculation is essential in order to obtain the necessary mechanical washing action the amount of make up should be ample to prevent dirt accumulation. Here again substitute pressure as far as possible for volume to improve the mechanical effect of a smaller amount of water.

Foam is dangerous and should be kept at a minimum. Even foam above boiling vats may be at a low enough temperature to nurture serious infection.

Can coolers using countercurrent-flow with small water-to-can ratios not only have the advantage of little water in residence and even that for a short time but also permit the water to heat up enough so that useful heat may be recovered. Immersion can coolers, whether continuous or tank type, with a large volume of water in residence or using recirculated water may be controlled when necessary by water chlorination.

Fillers, as a class, are usually controllable, from a sanitary standpoint, only by periodic cleaning. Ready disassembly for such clean-up, therefore, is the prime consideration. Ease of accessibility of ports, surfaces and valve openings is also imperative. Those responsible for maintenance should be supplied with adequate brushes, solutions and other aids to clean-up, which will simplify and economize the job.

Food containers, used to bring product to the plant, and containers used for conveying partially prepared food

in the plant challenge the designer to produce adequate automatic cleaning machines. The familiar lug box and crate constructed of wood will probably always be with us. Wood containers for constant reuse in the handling of soft, juicy, or fragile products should be thoroughly cleaned and dried between each use. The use of low velocity water and low pressure water for this purpose often merely moistens the waste and soaks the juices into the wood. Again high pressure water properly directed can be of great assistance. Application of chemical disinfectants might be considered after cleaning and before drying. Pails and pans are often poorly washed by tired and hurried personnel. Continuous washing equipment would be surer and more effective.

Since food plants are so highly mechanized today, there is hardly any part except the floor and walls that cannot be considered a machine. Hardly any of the rest, not mentioned here, but offers its own unsolved sanitary problem to the engineer.

The problem of machine maintenance and design to insure high sanitary standards is of great magnitude. It will not be solved overnight or by a single factor in the food industries, but should be considered a field for cooperative effort by manufacturers, users and public agencies. It is a problem for evolution, not revolution.

BACTERIAL PROBLEMS IN USE OF TUBULAR BLANCHERS

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As early as 1926, bacteriological studies were conducted to locate the sources of thermophilic organisms in canned vegetables. (1) On the basis of the information available from such studies, the army realized during World War II, that tropical areas where high storage temperatures prevailed created a problem of thermophilic spoilage in canned food supplies for the armed forces. Accordingly, the Quartermaster Corps organized mobile field laboratories which inspected a large number of canneries during the 1944 and 1945 pea and corn canning seasons. By incubation tests and bacteriological sampling at selected points in the plants inspected, an attempt was made to designate for export to tropical regions, those packs which would be subject to a minimum of thermophilic spoilage if high storage temperatures should be encountered.

The activity of the Army mobile laboratories again focused the attention of the canning industry on the problem of thermophilic spoilage. A number of canners made arrangements to have this Division make more detailed bacteriological plant surveys to locate the exact source of the thermophilic organisms and determine means of eliminating them from the final product. Much of this work continued into the 1946 season.

During the seasons covered in this work, bacteriological surveys were made in a number of plants where the blanching of peas was carried out in tubular systems. This equipment comprises a large storage tank to supply the hot water for blanching, a jointed system of large diameter pipe up to several hundred feet long in which the peas are blanched, and units for mixing the product with the water and pumping the mixture through the piping. The pipe and fittings are usually made of plain steel or wrought iron and the piping system may be hung on the wall, on the ceiling, or in other arrangements suitable to the particular plant layout. After discharge from the blancher, the product is screened from the water. The water then returns to the storage tank, where, together with make-up water, it is reheated for continuous cycling through the tubes.

In some plants, this type of equipment has been employed for preheating whole grain corn. However, as compared with systems used to blanch peas, relatively short lengths of pipe were in use with corn, since the object was only to heat the corn through so that exhausting in the can would not be required.

Operations such as blanching, which are carried out at elevated temperatures, have long been recognized as important foci of infection with thermophilic spoilage types. This was pointed out by Cameron, Williams and Thompson (1), and later surveys such as those of Townsend, Esty and Stoner (2) have emphasized this point.

Compared with older types of blanching equipment, tubular type systems have been considered easier to clean because moving parts were open or could be opened readily for cleaning and inspection, and the piping could be thoroughly flushed after each operating period. Consequently, it was rather surprising to find during the course of field surveys that under actual operating conditions, this equipment could frequently be a serious source of thermophilic contamination. It is believed that discussion of some of the operating practices which were found responsible for the unsatisfactory bacterial condition of the tubular equipment and discussion of the significance of thermophilic contamination will be of interest to the industry, and may assist in reducing possible losses from thermophilic spoilage.

Field Surveys

Foam at Storage Tank—One condition which was found to be very conducive to the multiplication of thermophilic organisms in tubular blanching systems was the presence of foam on the water surface at the storage tank and at the product inlet. Temperature measurements in such layers of foam gave readings of 100° F. to 160° F., depending on the thickness of the layer and the proximity of the thermometer bulb to the water. Temperatures in this range are favorable to the multiplication of facultative and obligate thermophilic organisms and portions of the foam were nearly always at the optimum temperature for growth, circa 131° F.

One test on peas, which was made to obtain foam counts at two-hour intervals, showed a remarkable increase in flat sour spores in the foam during one shift at a plant where the blancher was drained and cleaned after each shift. In another series of tests on peas, counts were made for flat sour spores in the liquid from settled foam at periodic intervals over four days time. The lowest count found was 60 spores per ml. of foam liquid; most of the counts ranged between 100 and 600; and three samples showed spores too numerous to count. The effect of the foam in contributing flat sour spores to the blancher water is shown by the following counts taken on three different days on whole grain corn.

Foam liquid Flat sour spores/ml.	Blancher water Flat sour spores/ml.
200	75
76	12
210	125

Blanching Temperature—In some instances, blancher units were found operating in the lower range of temperatures for attaining the objectives of blanching or preheating, usually because of failure to provide for adequate heating of the volume of water required. In one case, through failure to check operating temperatures regularly, a blancher was operated so that the water was held at a temperature of 140° F. and a count of 101 flat sour spores per ml. was observed. When raised to 165° F., six counts during one shift averaged 30 per ml. During two days operation at 180° F., nine counts averaged seven spores per ml. in the blanch water. In another plant, raising the water temperature from 165° F. to 200° F. reduced the blancher water count very materially. In a third survey, where the blanching water was maintained at 200° F., the spore count per ml was never found to be more than five.

While more data are needed on the effect of various levels in the higher ranges of commercial blanching tem-

peratures, it appears definitely dangerous to maintain storage tank water temperatures too near the growth temperature range for thermophiles.

Washing After Blanching—The importance of adequate rinsing of the product with fresh water after blanching in reducing the bacterial load has been brought out by previous studies in this field (2). Tests made in connection with the present surveys show that this operation is equally important when tubular blanching systems are used. During one survey, six different sets of six cans each were hand filled with peas directly from the drain reel after the blancher. The cans were brined by hand and given the regular process. During incubation at 131° F., 34 of these 36 cans developed flat sour spoilage. At the same time that the hand filled cans were prepared, line samples which had received the regular wash following blanching were taken for incubation. Of these 20 controls only three cans developed flat sour spoilage when incubated.

At another plant where no wash after blanching was in use for the peas, processed cans were incubated at 131° F., and of 132 cans tested, 39 developed flat sour spoilage. Contamination with the spoilage spores was shown by cultural tests to be present in the tubular blanching system, and the lack of any rinse to remove blanch water appears to have contributed to the high rate of spoilage.

Cleaning Tubular Systems—Changes in operating conditions can minimize the build-up of thermophilic organisms in the blanch water during operations. However, if the equipment is not adequately cleaned, it may harbor spores of thermophilic bacteria which then contaminate the product, particularly the first lots run after shut-down periods.

Open units of the tubular system, such as water storage tank and drain reel can be readily inspected and scrubbed. The tube system is frequently permanently assembled and presents a more difficult cleaning and sterilizing problem. The inadequacy of ordinary flushing of the tube system is shown in Table I. Although the more extensive cleaning programs instituted were not completely effective, a marked reduction in spoilage was accomplished.

Table I

EFFECT OF CLEANING METHOD ON INCIDENCE OF FLAT SOUR SPOILAGE

	Type of cleaning program		
	A	*B*	*C*
Packing days	5	5	1
No. of cans incubated	60	60	12
No. of flat sours	29	8	2
Percent flat sour cans	48	13	17

A. Ordinary flushing. *B.* Circulation of hypochlorite germicide for 30 minutes at 170° F. *C.* Flushing with detergent, followed by overnight hold of cold hypochlorite solution.

At two other plants, detergent flushing followed by holding of cold hypochlorite in the tube system overnight (Program C in Table I) was more effective. Incubation of daily samples over a period of a week failed to show any spoilage in either case. These plants both had experienced thermophilic contamination in previous seasons, so it may be concluded that the cleaning method was a factor in eliminating the difficulty.

Discussion

The problems which thermophilic organisms impose on canners of vegetables are not new (3) (4) (5), but it may be of interest to review briefly their significance in the distribution of canned foods during peacetime. As a class, thermophilic bacteria are the most heat resistant which have been encountered in canning. For most strains, the numbers present in the cans at the time of processing must be rather small, and for a few strains, extremely small, if they are to be destroyed by standard processes. Conversely, processing schedules which will kill an appreciable contamination of these organisms are impractical from the standpoint of quality for most products. For example, one flat sour strain has been found to survive a process of 80 minutes at 250° F., when only 50 spores are inoculated into a No. 2 can of cream style corn. This process is 10 minutes longer than the process recommended for control of ordinary spoilage bacteria.

Thermophilic organisms, obligate as to growth temperature, multiply in the range of 110° to 160° F. Facultative thermophilic organisms are able to grow at somewhat lower temperatures, 90° to 100° F., but fortunately, this class is generally not as heat resistant as the obligate thermophiles. Considering these temperatures, such organisms which survive processing should not be able to cause spoilage in the final product under normal canning practice and distribution conditions. However, the potential hazard which exists results in a considerable number of thermophilic spoilage losses each year in domestic handling either from undercooling or from exposure to high storage temperatures at some time after canning. Thermophilic spoilage by gas producing anaerobes becomes readily evident by swelling of the cans but flat sours are, of course, more insidious. Many of them may reach the ultimate consumer with resultant loss of confidence in the brand involved. Even if discovered before distribution, flat sour spoilage can be segregated only with difficulty, if at all, and entire lots may be lost.

In attempts to control the number of thermophilic organisms at a level which will be destroyed by standard processes, three points of danger have been recognized (6) (7), namely, the raw product, added ingredients, and build-up in the processing equipment. With the widespread use in the industry of certified sugar, starch and similar ingredients which comply with the National Canners Association tolerances for thermophilic spores, these materials have ceased to be a general source of contamination of the product. The raw product may be the means by which thermophiles originally enter the plant, but the numbers found in the washed, prepared raw food seldom constitute a direct spoilage hazard. Multiplication of the bacteria in the equipment so that foci of infection become established, has been found to be the principal cause of most outbreaks of thermophilic spoilage in recent years.

Recommendations

From the above data and discussion, it is apparent that significant spoilage hazards can exist in the operation of tubular blanchers. Recommendations for minimizing the possibility of thermophilic spoilage losses arising from contamination in this type of equipment are listed below.

1. Foaming—Trial on a limited basis has indicated that changes along the following lines will help keep excessive foam from accumulating at the storage tank and product inlets: (a) a large overflow, across the full width of the storage tank is desirable as a foam outlet; (b) intensive sprays of water on the top of the storage tank directed at a flat angle to the water assist in driving accumulated foam out the overflow and sprays around the product inlet help break foam at this point; (c) the water heating arrangement should be designed to create as much as possible a rolling motion of the water toward the overflow end of the tank.

2. Blanching Temperature—Automatic regulation of the heating of the storage tank water and maintenance of the temperature at as high a level as is consistent with desired blanching results will aid in keeping all parts of the system at temperatures above the growth range for thermophilic organisms.

3. Washing after Blanching—Adequate spraying of the product after blanching with fresh water, cold or hot as required, is recommended to reduce the number of organisms carrying over into the can as a result of contamination in the blanch water.

4. Cleaning Procedures—The practical elimination and exclusion of thermophilic organisms from the blanching system may require more than ordinary sanitation of the equipment. Some of the procedures which may be needed are: (a) dismantling and scrubbing with efficient detergents of all open units; (b) use of detergents and germicides in the pipe system after the initial washing; (c) holding of cold germicide solution or cold water in the pipes during the night shut-down; (d) steam pressure sterilization of the tube system after

thorough detergent washing; (e) draining of the system during minor shut-downs, or maintaining circulation at temperatures above the thermophilic range.

Summary

Several conditions in the operation of tubular type blanchers have been shown by bacteriological surveys to foster infection of the product with thermophilic bacteria. Accumulation of foam at the storage tank and use of low blanching temperatures permitted multiplication of these organisms, even during the operating period. Rigorous procedures for cleaning this type of equipment were helpful in reducing the spoilage hazard, and in common with blanching by any means, rinsing off the blanch water reduced the number of organisms carried into the filled cans.

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RESEARCH NEEDS IN THE CITRUS INDUSTRY

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It is perhaps as well that your speaker had only a few days in which to prepare this discussion of the research needs of the citrus industry. While the shortness of time made it impossible to attempt a complete analysis, or append a list of references, it also discouraged the tendency to overestimate what research can accomplish.

It is not my intention to disparage the value of research, nor to deny the need for research in the citrus industry. The point is rather that research should not be expected to furnish an easy solution for all difficulties.

This discussion will not attempt to indicate all research needs of the citrus industry. Instead an effort will be made to describe three groups of problems which appear to be urgent to canners and which may be similar to problems which exist in other fruit and vegetable industries. While overlapping of these problems prevents concise classification, the discussion will be divided into three parts:

(1) Market Research (2) Improvement and Standardization of Manufacturing Methods and Finished Products (3) The Development of New Products.

Market Research

While it isn't conventional to discuss market "research" before a group of technologists, in this instance something is meant beyond surveys and analyses which technologists consider important preliminaries to, essential bases for, and integral parts of,—but not in themselves,—research.

It appears fairly certain that one of the most urgent research needs of the citrus industry at the present moment is to determine by experiments and tests how the eating habits of the American public can be influenced so that the entire population will purchase and consume *at least half* of the *minimum* nutritional requirements of citrus fruits and products at prices which will return not less than the cost of production to growers of the fruit. As the entire crop of oranges and grapefruit is equivalent to *less than a third* of *minimum* needs such a development would necessitate the importation of supplemental quantities of citrus fruits and products and would stabilize the marketing of citrus fruits and products as staple foods.

In considering our nutritional requirements of citrus as a basic food, it must be confessed that our knowledge of nutrition hasn't progressed very far since Ambrose Bierce defined a wholesome food as "a worm to a frog, a frog to a snake, a snake to a pig, a pig to a man, or a man to a worm."

On the other hand, when flavored and colored mixtures of sugar and citric acid, with a pinch of synthetic ascorbic acid are advertised to hospitals as health "foods" equivalent to fruit juice, and when packers of flavored and sweetened powdered milk (an excellent basic food requiring no crutches) add a few synthetic vitamins and imply that a glass of the beverage is equivalent to a four-color page-full of fruits, vegetables and other natural foods, it would appear that the packers of citrus products selling for less than the cost of production need to consider using all favorable evidence from reputable sources in promoting the nutritional importance of these foods.

Nutritional Needs

Surveys by the National Research Council, the U. S. Department of Agriculture and other investigators unanimously agree that in this, the best fed nation in the world, half the people suffer from malnutrition,—not the gross deficiencies which are apparent to casual observation, but the hidden hungers which result in subnormal development of bones, teeth and body tissues and in impaired resistance to infectious diseases.

These surveys further reveal that it is not lack of availability of basic foods which is primarily responsible for conditions which exist. On the contrary, the prevailing pattern of inferior food habits is the substitution of excessive quantities of refined foods —such as sugar, starch, distilled liquors, refined oils, polished rice, highly milled flour—for the basic natural foods which would supply minerals and vitamins necessary for normal development and health. There is no harm in refined foods, but the fact that they comprise a large portion of our diet emphasizes the importance of including in our daily diets compensating quantities of natural foods richest in essential minerals and vitamins. These foods have been divided into six groups which are:

1. Cereal products, particularly those containing portions of the grain rich in minerals and vitamins.

2. Dairy products, including milk, butter and cheese.

3. Meat, fish and poultry products, including eggs.

4. Fruits and vegetables, generally.

5. Fruits and vegetables, rich in carotene, and

6. Citrus fruits.

Food Values in Citrus Fruits

This discussion will be confined to citrus fruits and products, but it appears reasonable that the problems affecting the packing and distribution of these foods resemble those affecting the packing of other basic foods. Although a nutritional deficiency of great prevalence in all income groups is in food elements abundant in citrus fruits; although our total crop of oranges and grapefruit is equivalent to only a third of our minimum requirements for balanced nutrition; although the citrus industries in American producing areas are doing an excellent job of sales and publicity pro-

motion and consumer advertising; although it is possible to produce and deliver to consumers oranges and grapefruit and canned juices at prices that make these foods outstanding bargains in today's food market,—recent prices have been at levels which failed to return costs of production and distribution.

Consumers may purchase abundant supplies of canned citrus juices at less than a cent an ounce, less than the price of soda-pop! Carbonated beverages are pleasant and convenient thirst quenchers with no food value except their sugar content. Canned citrus juices are also pleasant and convenient thirst quenchers with an approximately equal sugar content. In addition, research reports indicate that citrus juices are richest available food sources of ascorbic acid, citrin and inositol, and are good sources of naturally balanced B factors and minerals to compensate for the large proportion of refined foods in American diets.

When consumers fail to deplete markets of canned citrus juices at prices lower than soda pop, and growers receive less than production costs for fruit, research must be needed on the problem of altering American food habits so that sufficient citrus is eaten to protect the health of consumers and insure that this crop is sold at prices which will encourage continued production.

Vitamin C in Citrus Juices

Research sponsored by the National Canners Association, the Florida Citrus Commission, the Nutrition Foundation, the California Fruit Growers Exchange and others has revealed the success of improved canning methods in retaining water-soluble B and C vitamins in citrus juices.

Citrus fruit has received its greatest publicity as a rich and stable source of vitamin C. Dr. C. G. King, Director of the Nutrition Foundation, discussing home methods of food preparation, stated: "With the exception of citrus juice, 80 to 90 percent of the vitamin C content of the diet is regularly lost between the market and the dinner plate."

Scoular and Bryan, reporting tests of school lunches planned by dietitians and served at the North Texas Teachers College Demonstration School found that the only day during the test period that lunches were not grossly deficient in ascorbic acid was when an orange, served as dessert, supplied 97 percent of the vitamin C content of that lunch.

Other Vitamins

The spectacular value of citrus fruit as a source of vitamin C has been demonstrated in human and animal tests on calcium metabolism and dental health. However, less well known nutritional factors in citrus fruit are of equal importance. Citrin has no less value as a capillary fragility factor, although it has defied efforts to isolate and purify it without destroying potency. Evidence is accumulating, not only of its favorable influence upon the utilization of vitamin C, but also of its value in preventing blindness from hemorrhagic retinitis and for treating certain forms of hypertension and psoriasis. Limited evidence indicates that it may have value in preventing erythroblastosis in pregnancies involving Rh negative mothers and Rh positive infants. Citrus fruits are rich sources of citrin. Raw or canned juice may supply normal needs, while sufficient concentrates for clinical requirements can be recovered from peel residues from processing.

Inositol Abundant in Citrus

Another vitamin abundant in citrus fruits is inositol, which got a bad start because it failed to cure or prevent baldness, a virtue surmised or hoped for by early investigators. It is now becoming recognized as a lipotropic factor which may have a balancing influence in minimizing damage to the liver as a result of unbalanced diets or self medication with synthetic vitamins. As both citrin and inositol are abundant in citrus peel, these substances may contribute to the reputation which dried citrus peel has as a "conditioner" or "tonic" in cattle feeding!

Other Rich Contributions

Citrus fruits are not only rich sources of ascorbic acid, citrin and inositol. They also contribute naturally balanced B complex factors and minerals to the diet. The facts uncovered to date are all in favor of the benefits to be derived by the public from tripling the consumption of citrus fruits and juices. The problem of promoting a general realization of these facts is something like the weather:—people talk about it, but so far, relatively little has been done to extend and supplement standard advertising and sales promotion methods. It is reasonable to believe that packers of citrus juices may promote public recognition of the importance of these foods by working with professional people in a position to influence eating habits. This will include those who practice and teach medicine, dentistry, dietetics, home economics and allied sciences. The California Fruit Growers Exchange has prepared a colored motion picture which strikingly illustrates the value of citrus juices in increasing the rate and strength of wound healing following abdominal surgery. This has been acclaimed by physicians, dietitians and nurses, and its success illustrates the possibilities in this field.

Citrus Fruits Fill Vital Nutritional Need

An urgent research need of the citrus industry today is to determine the quickest and most effective means for bringing to the entire American Public a realization that citrus fruits are not luxuries but staple foods.

Six ounces of juice or an equivalent quantity of fruit is necessary in the diet every day to avoid deficiencies. A pint or more per day is desirable for nursing and expectant mothers, for invalids and elderly people and for every one, to furnish, together with other basic foods, optimum protection against such infections as colds.

The problem of modifying the eating habits of sixty million Americans isn't an easy one. The cultivation of educational agencies is obviously desirable. Children accustomed to regular adequate quantities of citrus juices and other basic foods in school lunches will take healthier bodies and superior eating habits into their homes and adult lives. As public health and stabilized agriculture are both important to national welfare, government support for educational work is warranted and should have a more permanent value than subsidies.

Intensive cultivation of professional groups in a position to influence eating habits appears indispensable. The fact that all the answers aren't readily apparent is evidence of the importance of market "research" to determine most effective channels which promotion should follow. Technologists should share in developing effective plans to this end.

Improvement and Standardization of Processes and Products

Probably the second most urgent research need of the citrus products industry is for improvements in processes and products. The citrus products industry has grown up fast. Citrus juice canning has become a leading industry within a few years. As a result of cut-and-try experimentation by federal, state, commercial, equipment and can manufacturer, and Canners Association technologists, methods have been developed for (1) extracting and screening juice with a minimum incorporation of undesirable constituents, (2) handling juice rapidly, continuously and uniformly, (3) avoiding unfavorable effects of enzyme action or contact with copper alloys, (4) de-aerating and de-oiling by methods which contribute to the standardization and stability of canned juice, (5) heating and cooling juice rapidly and uniformly while it is agitated to avoid local overheating and (6) closing it in cans with a minimum of oxygen or other contaminants.

As a result of these methods freshly canned juice from the best plants has a flavor and food value fully as good as that of raw juice. However,

flavor and food value may deteriorate during storage at rates varying with type of fruit and storage temperature. Grapefruit juice is most resistant to the unfavorable influence of high storage temperature. Other citrus juices, in the order of resistance to high temperature storage are: orange-and-grapefruit blend, orange, tangerine, lemon and lime. At uniform temperatures (in an incubator) above 95° F. citrus juices tend to deteriorate objectionably within a few months. At average storage temperatures, not exceeding 80° F., citrus juices maintain satisfactory quality for one or two years or longer. At a uniform storage temperature of 0° F., orange juice sealed in cans showed no appreciable loss in flavor or ascorbic acid after five years.

Concentrated orange juice reacts similarly except that it is more subject to the unfavorable influence of high temperatures. When concentrates are stored at excessive temperatures, the rates of darkening, staling and loss of ascorbic acid follow parallel curves.

Need for Basic Research

At present, research needs of citrus juice canners and concentrators include fundamental work upon the ultimate composition: the acids, glucosides, sugars, nitrogen compounds, enzymes, vitamins and other compounds present in varieties of fruit in each of the producing areas as maturity progresses. While much information has been accumulated on the proximate composition of citrus fruits, very little is known regarding ultimate composition. Assays for all known vitamins; accurate measurements of the kinds and quantities of sugars and acids; studies of the activity of enzyme systems and similar work might supply information which would be valuable for improving maturity standards, processes and products and would probably contribute to our knowledge of the nutritional function of citrus fruits. A practical problem is further improvement in juice extractors to increase sturdiness and ease of cleaning and secure higher yields, and better quality of juice.

Problems of Sanitary Control

Another problem of importance is microbiological control. The first step is in the delivery of fruit to extractors with as nearly sterile surfaces as may be practical. As most juice extractors require sizing of fruit, and fruit sizers are not designed for washing, the only practical method of preventing infection of fruit by organisms accumulating on sizing equipment is to be certain that fruit delivered to sizers is sorted to completely remove spoilage, and that fruit surfaces are substantially free from microorganisms and are completely dry.

Experience in our plant indicates that thorough cleansing of fruit and equipment by effective detergents is more valuable than the use of antiseptics. Procedures have been developed which permit holding microorganisms by colony count methods below 50,000 per milliliter in raw juice under most operating conditions. Additional research is needed to improve detergents, and methods for cleaning fruit and equipment as unpasteurized products assume an increasing importance in the marketing of citrus fruit.

Citrus By-products

Other special problems arise in every phase of citrus products manufacture. Standardization of Citrus Final Syrup or molasses is currently urgent. This syrup is used in animal feeding and in the fermentation industries as a culture medium and as a source of fruit spirits. Wide variations exist in handling of citrus cannery residues, in methods of liming and pressing, in degree of pre-heat prior to storage of press liquor. Variations in composition and pH are of greatest immediate importance because of different uses for the syrup and because of undesirable chemical reactions which may occur in storage tanks of customers when syrups from two manufacturers are mixed.

The Development of New Products

The development of new products will always be an important research need of the citrus industry. Nothing stays the same; and only by looking ahead can any industry avoid obsolescence.

At present, a new citrus product which promises to become important is frozen concentrated juice. It is well known that citrus juice can be preserved for long periods by uniform frozen storage in gas-tight containers. However, container, storage and distribution costs are high; and it is difficult to defrost frozen juice without impairing quality.

To overcome these objections research workers of the Florida Citrus Commission investigated the possibility of preparing three-to-one and four-to-one concentrated orange juice products which could be distributed in frozen form and could be reconstituted quickly and easily, the water thawing the concentrate and the concentrate chilling the water so that juice can be prepared for serving without damage to flavor or food value. Four-to-one concentrate was prepared by mixing approximately equal volumes of single strength juice and 65° Brix concentrate prepared by evaporation at temperatures below 60° F.

Commercial operators and equipment manufacturers have worked together in developing special processes and equipment to manufacture this product continuously at nominal cost, considering the engineering problems which are involved. Although abnormal conditions in the equipment industry have retarded commercial operations, the prospect is that increasing quantities of these new, superior concentrates will be available in the not too distant future. Samples of products have been universally greeted as the best yet available for public serving where flavor is a primary object. It may be anticipated that this will be a fancy product at a premium price.

At the University of Florida, work is being conducted on the possibility of developing commercial methods for preparing concentrates for frozen distribution—by separating water from juice fractionally by crystallization. Continued research in this field and investigation of the possible value of the Linde-Krause procedure, developed in Germany, may result in developments of advantage to the citrus industry.

Research is needed on the possibility of developing other new processes and products which will use substantial quantities of citrus fruit in products to aid in stabilizing the marketing of citrus crops.

Conclusion

In this discussion of research needs of the citrus industry, your speaker has endeavored to summarize a few points of importance. A subject which might have been mentioned is the need for a more comprehensive abstracting of current literature of food technology. This subject was discussed in the *Fruit Products Journal* for November, 1945.

In today's discussion emphasis was placed upon the promotion of the nutritional importance of citrus fruits and products. Recently, your speaker attended a national meeting of dietitians at Cincinnati, at which reconstituted orange juice was demonstrated. While the American dietitians were familiar with the uses and properties of the product and with its high retention of vitamins, a dietitian from England proved to be the most enthusiastic booster. She sampled the product several times each day, consuming generous servings while discoursing enthusiastically upon the record in war-time England. She knew that the concentrate was rationed to nursing and expectant mothers and children under five, and that despite abnormal war-time living conditions and restrictions on medical, hospital and nursing care, death in child birth and infant mortality dropped to an all time low, and infant health achieved an all time high.

I could not avoid the conclusion that the technical people of the citrus industry have fallen down on the job of furnishing ammunition and moral support for publicizing the virtues of canned citrus products.

PLANT INVESTIGATIONS WITH A MOBILE LABORATORY

By C. Wallace Bohrer, Washington Research Laboratories, National Canners Association

Canning plant investigations using a field laboratory equipped for bacteriological work were conducted by the National Canners Association for the first time during the 1926 canning season. The objectives of the initial field investigations were to discover and eliminate the causes leading to certain specific outbreaks of spoilage. Previous and extensive preliminary studies in the Washington Laboratory on spoiled canned foods had clearly defined the heat resistant spore-forming bacterial types responsible for spoilage, and suitable media and techniques had been devised for their detection and estimation. It was logical, therefore, that the bacteriological investigations be conducted in the field in those canneries which had experienced abnormal spoilage.

During the first year, five canning plants were studied and in the following year this number was increased to twenty. As a result of these investigations, it was apparent that the sources of significant contamination with spoilage organisms which could resist the heat processing might be located within the canning plant itself. Emphasis then was placed upon the routine examination of samples taken at key points in a large number of canneries to determine whether spoilage hazards existed. If spoilage hazards were found, remedial measures based on previous spoilage experience and the habits of the spoilage organisms involved were suggested. This marked the beginning of the National Canners Association field laboratory service to members.

The first field laboratory consisted of the necessary equipment packed in boxes which were shipped by rail to the canning plant where the investigation was to be made. Considerable time and effort had to be expended in setting up and organizing this field laboratory. In 1928, the equipment was redesigned, and carried into the canning areas by means of a truck, which made greater coverage possible.

The mobile field laboratory services were increased and expanded and each year new experience and information as to the nature of spoilage hazards and their control was gained. The early investigations were concerned with the pea and corn packs, but gradually other products, such as spinach, pumpkin, asparagus, and tomato juice were included. It was found that experience gained in controlling spoilage or eliminating hazards in one product could be applied to other products.

In 1931, a smaller field laboratory was assembled and this unit has been held in complete readiness for emergencies since that time. If impracticable to move the truck laboratory to the source of trouble, the small unit is shipped by express, and personnel to man this laboratory proceed by train. It is felt that availability for emergency calls constitutes a valuable function of the field laboratory service.

How Surveys Are Conducted

Bacteriological field surveys are conducted at the present time in the following manner. Well in advance of the packing season, the product or products and the canning areas to be surveyed are decided upon. Decisions are based on spoilage experiences, requests from the industry, and prevailing conditions. Attempts are made to rotate the areas to be surveyed from season to season. If the need is pressing, a product and area may be surveyed during two successive seasons.

When the products and areas have been selected, all members in the areas packing the products to be investigated are notified of the intended survey. If they desire the service, they so indicate by letter, giving the location of their plant or plants, the name of the superintendent to contact, and the approximate opening and closing dates of the pack. The plants are spotted on a map of the area. After all requests are in, the area is divided into convenient sections and a central location chosen in each section for setting up the field laboratory. At the start of the pack, the laboratory is set up at a convenient headquarters plant, and samples are picked up by car from the neighboring canneries. Samples of the product under survey are collected at selected points in the packing line and tested for concentrations of organisms capable of producing spoilage.

As an illustration, in a pea survey, the samples usually collected from each line in operation are blancher overflow water, washed blanched peas, brine, and an unprocessed line can of peas as it leaves the closing machine. In addition, twelve cans of peas which have received the completed process are taken to correspond with the time of sampling. The line samples are subjected to bacteriological tests to detect the presence of spoilage organisms and the processed cans are incubated at 98 °F. and 131° F. and observed for the development of any spoilage. The organisms of spoilage significance in the case of peas and other non-acid products are the flat sour organisms, the thermophilic and putrefactive anaerobes, and the sulfide spoilage organisms.

If tomato juice is under survey, the principal sampling points are chopped tomatoes, juice after extraction, juice from holding tanks, and an unprocessed line can of juice. The sampling points may be varied, of course, according to the packing procedure used. Six processed cans of juice are taken for incubation at 37° C. Tests are made for total bacterial contamination and specifically for types capable of spoiling the juice, i.e., thermoacidurans and butyric anaerobes. The bacteriological results are available within 24 hours, and an attempt is made to contact each plant at least twice during the survey period.

If spoilage hazards are encountered, the superintendent is notified immediately either by phone or directly and spoilage control measures are suggested. Additional checks are made to determine the effectiveness of the control measures. Preliminary reports are made during the survey, and after the survey is finished formal reports are sent to each canner summarizing the complete findings and the suggestions made during the season for his reference in planning for the next packing season.

Sources of Contamination

Some of the chief sources of spoilage contamination have been and still are wooden equipment, blanchers, fillers, blenders, mixers, pumps, dead-end piping, sugar and starch. At any time, situations conducive to potential or actual spoilage may occur. A change in the packing procedure may introduce a dead-end in the piping or a new hot point which can easily become the focus of spoilage contamination. As an example, taken from the past season's work, a belt carrying cut corn to the filler was surrounded by a steam jacketed chamber to increase the temperature of the corn before filling. The belt became heated during operation and was slow in cooling down during shut-down. Thermophilic flat sour organisms found this belt an excellent haven for increasing their numbers, and spoilage of the product occurred. This situation was remedied after the field survey findings and future spoilage was prevented. In another recent case, a new type filler allowed the product to cool down to thermophilic temperatures during actual operations with subsequent increase in thermophilic contamination and spoilage. This was picked up by the survey tests and the contamination controlled.

There is the possibility also of new types of spoilage in old products, as well as spoilage in new products. In 1942, spoilage by a butyric anaerobe in tomatoes occurred, as one example. Back in 1933, spoilage by the thermoacidurans organism in tomato juice may be cited as another example.

Value of Surveys

The value that members place on field service is reflected in the many requests for the service when the survey program is announced. These constitute some of the reasons why we, at least, feel that there is need for continuing field laboratory service. It is of interest to note that Dr. Cameron

reported on the results of the first field laboratory studies at the 1927 Convention in Atlantic City, just twenty years ago. Since that time, some nine hundred canning plants in nearly half the states of the Union have been under bacteriological survey and over twenty different products have been studied. These products, in addition to those already mentioned, include sweet potatoes, succotash, mushrooms, sardines, shrimp, spaghetti, pork and beans, string beans, and just recently, non-acid type baby foods.

The only forced curtailment of field laboratory services occurred in the depression years 1932-1935 for economic reasons, and during the war years 1942-1945, because of reduced personnel and restrictions on gasoline and tires. During these periods, field work was limited to emergency investigations in those plants in which spoilage problems were encountered and where specific requests were made for field laboratory work.

Army Surveys During World War II

In 1944, the Subsistence Research and Development Laboratory of the U. S. Army Quartermaster Corps, placed in operation a large mobile field laboratory in the form of a trailer type truck for making surveys in canning plants preparing foods for overseas shipment. Various staff members of the National Canners Association worked with the Quartermaster Corps on the design and operation of this unit during the entire 1944 season. In 1945, two additional large mobile laboratories were placed in operation by the Army. The Washington Laboratory was called upon to train the Army personnel assigned to these units in field laboratory methods. After the training course, large-scale surveys were undertaken by the three Army field units and National Canners Association staff members served in an advisory capacity, both in the conduct of the actual surveys and later in the analyses of the results.

During 1946, full-scale mobile field laboratory studies were resumed using the National Canners Association truck laboratory with bacteriological surveys on peas, corn, and tomato juice in New York State. These studies were concerned, as in the past, with general factory surveys and investigations of special spoilage problems. Over 75 percent of the membership in that area canning peas, over 60 percent of those canning tomato juice, and over 80 percent of those canning corn requested the service. All in all, 74 plants were covered by the field laboratory last year.

Full Mobility Desirable

In field laboratory surveys, the greatest flexibility of movement possible from one area to another is desirable. The present field laboratory equipment is carried in a ¾-ton panel truck. As survey areas are changed, this equipment must be loaded and unloaded each time. There is the disadvantage also that only certain canning plants with suitable space facilities can be used as a headquarters for setting up the mobile field laboratory on survey. This often requires long trips by car to reach the other 20 to 30 plants in the section in the survey and permits only short contact with them. The staff's experience with the Army mobile field laboratories showed an unusual speed and coverage with a complete laboratory on wheels. It is felt that a truck laboratory of the type used by the Army is too large to be manned properly by the limited N.C.A. field personnel. A trailer type laboratory of more reasonable size can be obtained by refitting an ordinary house trailer, and this would be adequate to give the National Canners Association laboratory a flexibility of movement and coverage consistent with an expanded program of field laboratory work. Such a trailer has been purchased and installation of the necessary equipment is under way.

Since the trailer laboratory will be complete in itself, requiring only a source of water and electric current, it will be able to function at any canning plant regardless of size. Advantage will be gained therefore in that the sections in an area under survey can be narrowed and four to eight plants investigated at one time with any one of them serving as the headquarters for the trailer laboratory. This will permit closer contact between plant and field laboratory personnel.

In 1947, it is planned to make bacteriological studies on citrus products in Florida during the winter season and surveys at pea, corn, and tomato juice canneries in the Midwest during the summer season, and for these it will be advantageous to make use of the trailer laboratory. The ¾-ton truck will be retained for emergency use. This trailer laboratory can be used also for other field activities such as waste disposal and sanitation, either during the canning of seasonal vegetables or in the winter months. In this manner and by judicious planning, it will be possible to give greatly increased mobile field laboratory services to member canners.

ORGANIZATION OF QUALITY CONTROL IN CANNERIES

By J. E. Hall, Pictsweet Foods, Inc.

Oliver Wendell Holmes once said—"A Word is not a crystal, transparent and unchanged; it is the skin of a living thought and may vary greatly in color and content according to the circumstances and the time in which it is used."

The term "Quality Control," once an honored phrase, has come to have a great many different meanings to a great many different people. There are good connotations and there are bad connotations. Quality control systems vary from those with general and plant laboratories and experienced technical personnel to those consisting of a high-school boy checking fill-in weights—sometimes. Some concepts of quality control systems would be amusing if they were not serious. There is something amusing about the packer who buys a microscope and hires a so-called "quality expert" to impress his buyers but there is nothing amusing about any conscientious packer erroneously placing his faith in such a combination.

Some people think of quality control systems as packages which can be purchased by hiring food technologists. Some people think of quality control departments as a millstone to be hanged on the neck of a reluctant production department to watch and make it pack quality. Others as mentioned previously, think they are fine—everyone is talking quality and a Quality Control Department will impress the buyers. The expense will be charged to sales.

Reasons for Quality Control

In approaching the problem of organization of quality control perhaps we can find a solution by finding the answers to three questions: (1) Why should a canner want to pack quality? (2) How is quality obtained? (3) What might be done? In the discussion to follow we should recognize that a quality control system is a mode of operating or an operating philosophy. A quality control department is just a part of the system and a laboratory is only a part of the department.

The function of the canning industry in our free enterprise society is to pack good wholesome foods for consumers, thus providing jobs for workers, outlets for farmers and profits for the invested capital. Canners therefore are in business to make profits by fulfilling the basic function of this industry in society. The industry also has obligations which will be touched upon later.

Over and above the good wholesome food level, which can be considered the standard grade, consumers are willing to pay more as quality premiums, in proportion to their presence, for certain tangible and intangible product possessions which are usually called collectively "quality." In other words quality might be defined as that for which the consumer is willing to pay more in proportion to its presence and less because of its absence. Quality grades are the degrees of consumer acceptance. This is why fancy grade products sell at a higher price than extra standard

products. The differences in price between grades can be called quality premiums. It would follow, therefore, that the reason why canners should want to pack quality is to increase the sales value of their packs by securing the greatest percentage of quality premiums over the standard grade with a minimum expenditure for the increased value obtained, remembering that calling a product fancy does not make it fancy.

The packing of food products for which consumers are willing to pay more is no more accidental than the building of any good product, whether it be an automobile, washing machine, or house. The engineer or architect might lay out the soundest of plans but unless they are executed properly by skilled craftsmen the end result is not usually good. Quality, as some one once said, is the result of intelligent effort plus the will to produce a superior product. Each employee of a cannery influences to some degree the quality of the product: the cost accountant by failing to recognize the hidden cost of not securing the quality premium might insist on a reduction of apparent costs adversely affecting the degree of consumer acceptance; the filler operator by underfilling or overfilling; the porch man in the segregation of crops; and the fieldman in the production of crops exert their influence. Each employee influences the quality of the pack. The manager must co-ordinate and direct the activities of field and plant and each supervisor under him must likewise coordinate the activities of his group all to the common goal of the production of foods for which the company will get quality premiums. To exert this intelligent effort each must know what to do, how to do it and if it is being done. They must have sound reliable information at the time of packing on which to exert this intelligent effort. The decision to provide this information is the reason for adopting a quality control system. Obtaining and providing this information are the two principal functions of a quality control department.

What a Quality Control Department Does

The Quality Control Department at the management level, in cooperation with all other company departments, should establish packing procedures and company standards of quality. In establishing procedures and standards it must analyze data obtained from the actual packing operations, trade papers, independent investigational work and the good practical experience of the operating personnel. It must give consideration not only to what it costs to do a certain thing but also, from a monetary and consumer acceptance standpoint, what it means not to do a certain thing. It must pool the knowledge of the company on how to secure the greatest percentage of quality premium products in written form so as to lay down for the company rules on methods of operation for all to follow. This cannot be done in one year. Establishment of company standards of quality requires a keen appreciation of what the consumer wants—not what she will tolerate. Packing to trade standards is usually simpler than packing to brand standards.

The Quality Control Department at the operating level should be a series of checks set up to help the operating department conform to these established methods of operations and to the product specifications. It should provide the supervisory force with quick and accurate information on the quality of foods being packed and provide notice of deviations from the established packing procedures at the time the food is being packed so that corrective steps, if necessary, can be taken.

This may sound complicated but perhaps if we restate the original questions we will find that the answers apply to small plants and large plants alike.

First. Why? One reason alone why all canners should be interested in packing quality foods is to increase their profits by obtaining more of the quality premiums with the minimum expenditure for value obtained.

Second. How? The production of quality foods can be increased by providing the operating personnel with information on the best packing procedures and with information on the quality of foods at the time of packing so that they can exert intelligent efforts.

Third. What? Obtaining and providing this information and checking the plant operations can be done by a quality control department. Such a department can consist of one or more individuals depending upon the size of the plant.

One planning on establishing a quality control department should look upon it as a long term project because to be progressive it must constantly be finding better ways to do things and new things to do. It must recognize the things that can be accomplished and do them. It must recognize the things that cannot be accomplished and wait until they can be accomplished.

How To Set Up Quality Control

Much like the opening move in a chess game, the actual mechanism of organizing a quality control system is quite simple. Since a Quality Control Department is a tool to aid in the production of quality foods the successful use of this tool depends on the craftsmen using it. Those packers with limited production will probably find an individual with imagination, common sense, practical experience and some technical knowledge, easiest obtainable and best suitable for the work. Those with larger productions would probably want one with the same qualifications but with a higher technical background.

The old plant cutting room now becomes the laboratory. Space should be ample but not too big. The laboratory should be equipped with the simple instruments required to thoroughly examine the products to be packed. These would include scales, pans, draining screens, headspace gauges and the like. The expensive instruments for analytical, bacteriological and experimental work come later as their need is sensed and their use justified. For some products, such as tomatoes, a microscope will be a first year necessity. The equipment need not be elaborate but it should be adequate. Preferably the room should be located adjacent to the operating lines for convenience. If poor facilities are provided the chances are that the results will be poor. A cabinet maker can not do his test without good tools, adequate tools, and a good workshop. Neither can a food technologist.

The next step is setting up in simplest written form how the product should be packed. With a product such as peas, there might be specifications for grouping of loads or sieve sizes by tenderometric value to pack certain grades, blanching times and temperatures, fills, closing temperatures and processing times and temperatures. This will give the first tentative packing procedure and as it is built up over a period of years it will reflect the company "know how" on any product.

At the same time tentative product specifications should be set up in simple written form. The U. S. Grades in some instances will provide a good basis for some of the quality specifications but additionally the specifications should include weights, headspace, mold limits, in the case of certain products, and all other conditions which the can and contents must meet in order to conform to the grade or label. These specifications too will be subject to constant change as experience is gained. The guiding rule in setting specifications should be to give the consumer honest value for her money.

The next step is to write out a detailed set of instructions for some one to follow to check the operations and products being packed to determine if they meet specifications and if not, in what way they fail. As a further quality check additional samples should be examined several days after packing to ascertain the final condition of each lot.

This may sound simple, and quality control work the first year *is* simple. If the Quality Control Department is to find better ways to do things it must first learn what is being done so that improvements can be made. The data obtained by the routine examination of the products as they are being

packed, and after packing, will provide a wealth of material for the proper kind of individual to analyze for the company's betterment. The lessons learned the first year are applied the second. Each year thereafter there should be further efforts to improve, based on the knowledge of what has been done and how it has been done.

Some of our observations during the past several years may be of help to those considering the installation of a quality control system.

Rules for Quality Control

Responsibility. All quality control personnel should be responsible to the executive officers of the company and not to the operating personnel. It is the responsibility of the quality control people at the operating level merely to report deviations to the operating personnel. It is the responsibility of the operating personnel to correct conditions. There should be no conflict.

Laboratory Assistants. To do effective work the one responsible for quality control work can not spend all his time running routine examinations such as mold counts. Frequently it is found that routine work can be handled by less well-trained workers under proper supervision if they have complete written instructions, thus releasing the responsible person for original investigational work.

Forms and Records. Forms as drawn for use in the work are more useful if they are designed to show why a sample failed to meet specifications rather than the mere fact that it did. Knowing the conditions one can easily determine the score—but a score does not indicate the condition to be corrected.

Instructions on Procedures and Specifications. All instructions on procedures and specifications should be in written form and complete. All changes should be in writing since verbal changes only cause confusion.

Laboratory Tests. Each specification when possible should have an objective definition. Each laboratory check should be made carefully so that the results will be dependable. The National Canners Association Laboratories will be found to be very helpful in outlining these tests. The objective tests set up for labeling terms are well worth considering.

We in our company have been very fortunate in receiving from all of the operating people very helpful cooperation since all of us realize that only through good consumer acceptance of our products can we and the company prosper. Whether it be consumer acceptance or buyer acceptance the end result is the same.

This discussion on the organization of quality control was opened by a quotation from Oliver Wendell Holmes on the meaning of words. He described a word in part as the skin of a living thought. The living thought of the words "Quality Control" is the controlling of quality before packing, not determining the quality after packing. The consumer pays the cost of production and it is the obligation of the industry to pack foods the best way it knows how at costs which she is willing to pay.

CORN TECHNOLOGY SECTION

of Information Letter Supplement

Technical Papers from the Conference held January 20, 1947, during the Annual Meeting of the Corn Canners Service Bureau

INFLUENCE OF PROCESSING TECHNIQUE ON VITAMIN RETENTION

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CORN CANNERS' CONFERENCE,

The importance of canned foods as dietary sources of many nutrients has been well established by investigations conducted in several laboratories during the past 25 years. However, it is recognized that heat processing by conventional methods is accompanied by some sacrifice of quality and thiamine content in certain products. For the last fifteen years, research and development work on new or improved thermal processing techniques which would yield final products of higher quality and/or nutritive level has been particularly intensive. Since 1932, our Biochemical Group has been actively engaged in the evaluation of the effects of new processing techniques on the retention of vitamins in foods. Fifteen years ago progress in this type of work was necessarily slow due to the fact that laborious and time-consuming bioassay techniques requiring the use of animals had to be employed for estimation of vitamins in foods. Since the advent of the more rapid chemical, physical and microbiological methods for vitamin determination, a considerable amount of data has been accumulated in this laboratory which is currently being prepared for publication.

This report is of a preliminary nature and is designed to present briefly certain phases of our process evaluation work which are believed to be of special or particular interest to this section. The subsequent publication will fully describe the experimental procedures followed and methods used. Here it will suffice to present data on vitamin retentions established for two new processing techniques which have found commercial application during recent years as a result of development in our laboratories.

High-Short Processing Technique for Liquid or Semi-Fluid Low-Acid Products

The operation of the high-short processing technique, which involves an aseptic filling and closing feature (1) has been described by Pilcher and Clark (2). Briefly stated, the liquid or semi-fluid food is forced by pump through a tubular heat-interchanger system with the heating section maintained at temperatures in the range of 270° to 300° F., depending upon the product. At these temperatures, sterilization is effected in an extremely short time. From the heating section, the sterilized food proceeds through a tubular cooler and the cooled sterile product is finally filled into sterile cans and the cans sealed in a special aseptic filling and closing unit.

Studies were undertaken to determine the effect on thiamine and niacin retention in cream style corn of this high-short type of processing technique, as compared with the effect of conventional processing. Thiamine was chosen for study since it is known to be unstable to heat imposed during thermal processing. Niacin was included in the experiment because prior studies have shown this vitamin to be relatively stable to heat. The results obtained are presented graphically in

Figure 1

Effects of High-Short and Conventional Processing on Vitamins in Cream Style Yellow Corn

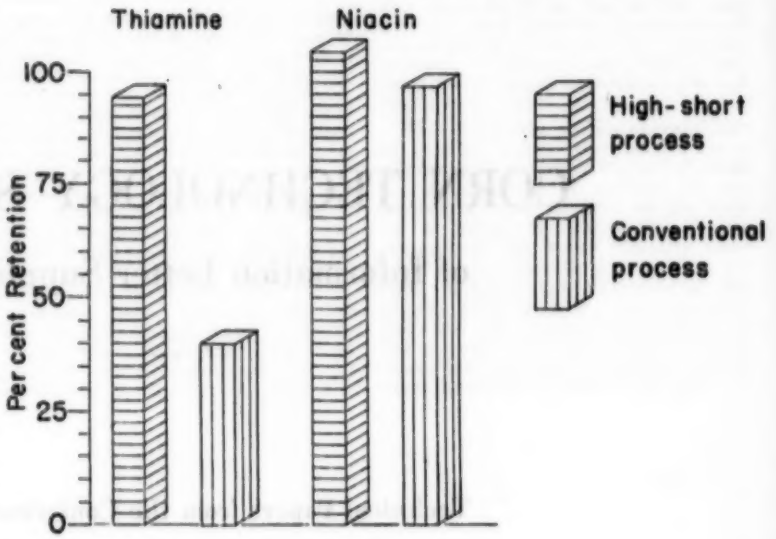

Figure 2

Retention of Niacin in Vacuum Pack White Corn Processed by Agitated Can and Conventional Methods

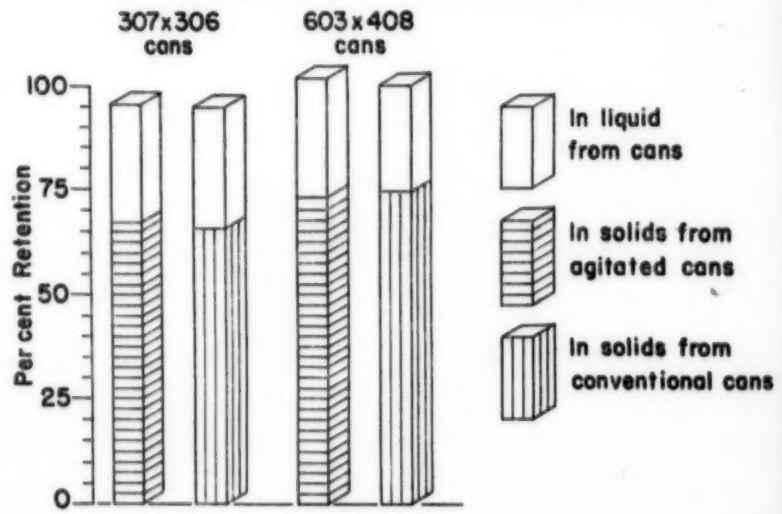

Figure 3

Retention of Thiamine in Vacuum Pack White Corn Processed by Agitated Can and Conventional Methods

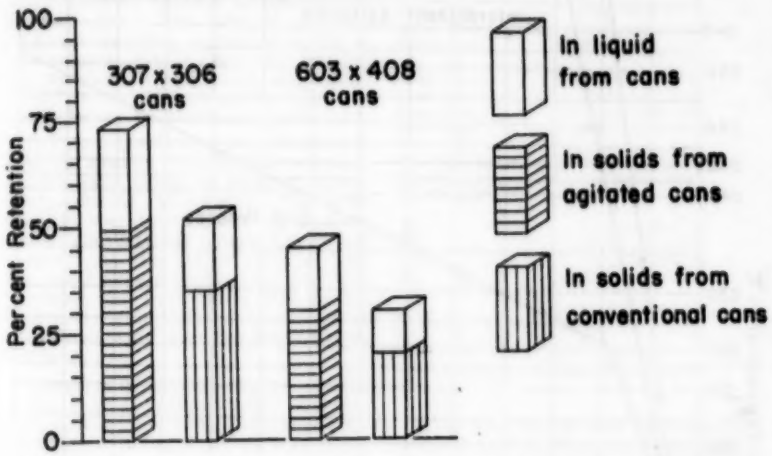

Figure 1 which shows the survival of thiamine and niacin in the final product after high-short and conventional processing. All packs were made from the same well-mixed batch of cream style corn.

As indicated in Figure 1, the percent retention of niacin in cream style corn is high in either the conventional or high-short method of thermal processing. However, the percent thiamine retention in the high-short methods is some two and a half times the percent retention during conventional processing. These data, as well as others obtained on other products to be reported in a later paper, clearly demonstrate the value of the high-short processing technique in thiamine retention in low acid products. The higher thiamine retention observed in the high-short process is due to the fact that in this type of process the ratio of the rate of thermal destruction of thiamine to the rate of thermal destruction of food spoilage bacteria is much more favorable to thiamine retention than the similar ratio existing in the conventional process.

Agitating Process for Vacuum Pack Vegetables

The agitating process for vacuum pack products and the details of its scientific development have been described by Roberts and Sognefest (3). Using the continuous axial or end-over-end type of agitation, a comparison was made between the thiamine and niacin retentions resulting from this type of agitated processing and the retentions obtained in the conventional still process for vacuum pack corn. The results are given in Figures 2 and 3 for both the 307 x 306 and 603 x 408 can sizes. As will also be noted, the percent retentions are shown both for the drained solids and for the entire contents of the cans.

From Figure 2 it will be seen that niacin retention in vacuum pack corn by either method of processing for either can size is uniformly high. However, Figure 3 shows that the agitating process technique gives distinctly higher retentions of thiamine. The corn processed by the agitated method contained 40 to 50 percent more thiamine than samples processed by conventional techniques in individual consumer size cans (307x306). Again this higher thiamine retention may be attributed to the fact that in this technique the ratio of the rate of thermal destruction of the vitamin to the rate of thermal destruction of food spoilage microorganisms is more favorable to thiamine retention than is the similar ratio in conventional processing. Thus, in addition to the improved quality in white and yellow corn reported by Roberts and Sognefest (3) as resulting from the agitating process, final products of superior thiamine values are likewise obtained.

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AGITATING PROCESSES FOR QUALITY IMPROVEMENT IN VACUUM PACKED VEGETABLES

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CORN CANNERS' CONFERENCE

Over the past 20 years, progressive canners and other agencies allied with the canning industry have been particularly active in attempts to improve the quality of commercially canned foods. Improvements made in varieties and strains of vegetables used for canning, care in harvesting at the proper time and rapid delivery to the canning plant have all contributed materially to superior quality in the raw product as it is received at the factory. Advances in principles and progress in design of canning machinery have also aided the canner in maintaining high quality in his product through the various steps involved in preparing it for the final packaging operations. Finally, means for maintaining quality in canned foods during thermal processing and subsequent storage have also been the objects of a considerable amount of investigation. The ultimate goal in vegetable canning is to bring to the consumer canned vegetables which possess the appearance and flavor of the natural garden-fresh, home-cooked product and which furnish the same general nutritive values.

The Vacuum Pack Method

During the late twenties, a new technique in vegetable canning was developed by this laboratory and, in 1928, tested on a commercial scale by several vegetable canners. This departure from the conventional canning practice of that time was named the "Geraldizing," method after its inventor, F. F. Fitzgerald. It is commonly known today by a more descriptive term, namely, the "Vacuum pack" method.

The vacuum packing procedure has made a significant advance in the direction of the ideal of producing garden-fresh canned vegetables. Whole kernel corn has proved to be the most popular of the vacuum packed vegetables and in 1945 alone, approximately 40 percent of the entire golden whole kernel corn pack was vacuum packed. However, other vegetables, including peas, green beans, carrots, beets and sweet potatoes, are also being packed every season in significant quantities.

Preparation for Vacuum Packing

Preparation of vegetables for vacuum packing is practically the same as for brine packing. The two

methods differ chiefly in the brining and closing operations. In the vacuum pack method, only enough brine is added to aid in increasing the rate of heat penetration to a point where a sterilizing process will give a product of good quality. One to two fluid ounces of brine are customarily filled into the standard 12 ounce can (307 x 306) and the filled and brined cans go directly from the filler into the vacuum closing machine. The covers are double seamed onto the cans under 25 to 28 inches of vacuum since considerable experience has shown that a closing vacuum in this range is required to produce the desired rate of heating of the can contents.

Thermal Processing

In general, vacuum packed vegetables require a more severe process to effect commercial sterilization than is required by brine packed vegetables. Typical processes for whole kernel corn are 25 minutes at 250° F. for No. 2 (307 x 409) brine pack and 35 minutes at 250° F. for 12 ounce (307 x 306) vacuum pack. Because of the darkening effect on the product imposed by the relatively severe process required for sterilization, white varieties of corn have never been successfully packed by the standard vacuum packing method. Conventional processing equipment such as standard horizontal or vertical retorts has been commonly used for vacuum packed corn.

Mechanics of Heat Transfer in Canned Foods

A canned food is commercially sterile when the thermal process has been sufficient to destroy or to render incapable of growth under normal storage conditions all micro-organisms capable of causing food spoilage which are present in the product. Since all parts of the container do not receive the same amount of heat in a conventional still process, provision must be made to get a sufficient amount of heat to the slowest heating point in the container. Foods, such as cream style corn, pumpkin and thick soups, in which heat is transferred by conduction, heat very slowly. By contrast, foods of light consistency and foods packed in brine heat mainly by convection and the rate of heat transfer is rapid. In illustration of this difference in heating rates, the customary process for a No. 2 can of brine packed peas is 35 minutes at 240° F.; however, 105 minutes at 240° F. is required to impart the same lethal heat value to a No. 2 can of pea puree. This one example will serve to show how the rate of heat penetration influences the processing requirements of canned foods.

Heat Transfer in Vacuum Packed Products

The method by which heat is transferred in vacuum packed products is quite different from that in cans where there is no similar amount of void space. The mechanism of heat transfer in vacuum packed products processed in the conventional quiescent manner has been explained by Jackson (1):

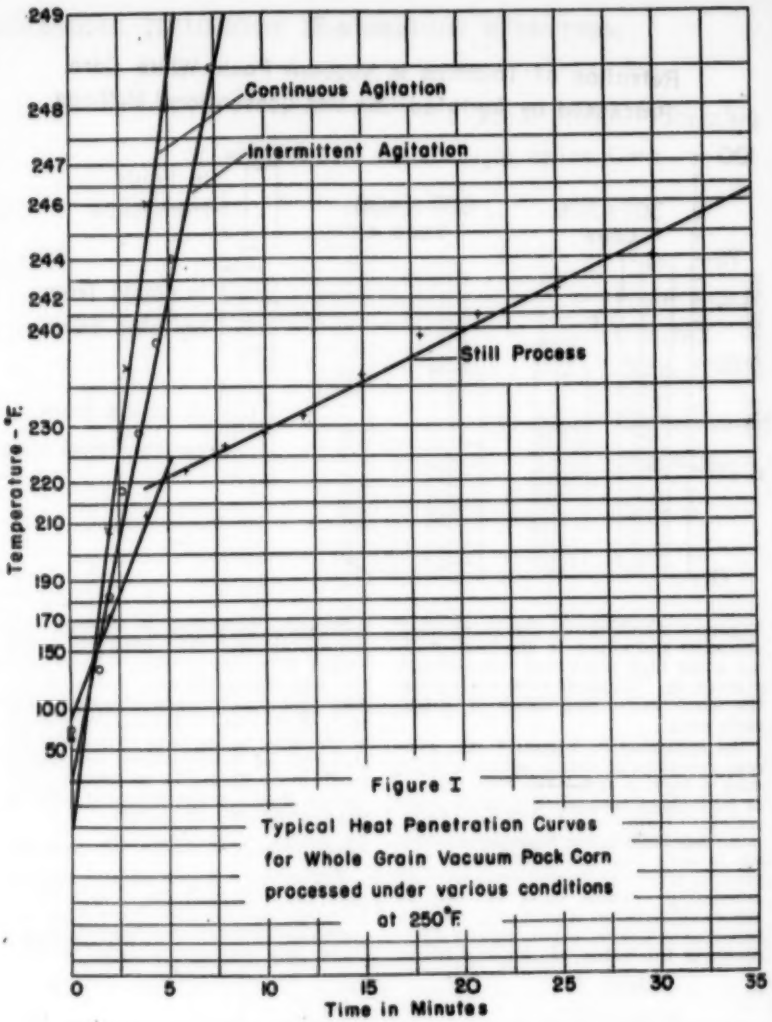

Figure I
Typical Heat Penetration Curves for Whole Grain Vacuum Pack Corn processed under various conditions at 250°F.

"The liquid in the can is easily vaporized at low temperatures in the low-pressure atmosphere. This warm vapor then circulates through the can and gives up some of its heat to the cooler food particles by condensation. The condensate flows down to the warmer parts of the can and is again vaporized. As the partial pressure of the gases in the can approaches the vapor pressure of the hot liquid near the outside of the can, the rate of heat transfer must decrease."

A so-called "broken" heating curve is characteristic for conventionally processed vacuum packed products. Such a product heats quite rapidly during the early part of the process but the rate of heating decreases appreciably as the temperature of the product approaches retort temperature. Thus, the heat penetration curve shows first a rapid rise and a sudden "break" and slower rate of temperature rise. The broken curve in Figure 1 is a typical heat penetration curve obtained on conventionally processed vacuum packed corn. It is this retarded rate of heating at the higher temperature that makes necessary the relatively longer processes for vacuum packed foods as compared to the same food packed in brine.

The Effect of Can Agitation

It is well known that with most canned foods, the quality of the product tends to decrease as the severity of the process increases. A great deal of work has been done on improving quality of canned foods by alteration

of process schedules without sacrifice of the sterilizing efficiency of their thermal processes. High temperature-short time processes and flash sterilizing techniques are outgrowths of continuing efforts to produce canned foods of outstanding quality, as pointed out by Ball (2). The field of vacuum packed vegetables appeared to be a particularly fertile one for fundamental work which would contribute to higher canned food quality through some change in processing technique.

In this connection, it seemed reasonable to assume that if the vacuum packed cans could be agitated effectively during processing, the heat transfer would not be entirely dependent on convectional circulation of hot vapors. As the can is agitated, the hot liquid should trickle over the food particles, lose part of its heat to the food and again become heated as it came in contact with the hot walls of the can.

Agitation of cans during processing is, of course, nothing new. Continuous agitating cookers have been used for years with brine packed vegetables and with juices. Batchwise agitating cookers have likewise been in commercial use for a long time for certain products. However, there appears to be no record of the agitating type of cooker being used to process vacuum packed products. Likewise, there has been no report on fundamental experimental work which might lead to the successful commercial application of agitating processes to vacuum packed vegetables.

Experimental Field Studies

Several years ago, heat penetration tests made in this laboratory using whole kernel corn indicated a greatly accelerated rate of heating resulted when the vacuum packed cans were agitated during processing. The much shorter processing time required for sterilization when the cans were agitated during the process yielded products of exceptionally high quality. The results of the original laboratory work, therefore, appeared to justify an extensive program of field studies which would establish the commercial possibilities of this type of processing for vacuum packed products.

Heat Penetration Studies

In the first approach to this problem, a batch type retort which is commonly used in the evaporated milk industry was fitted with suitable can-holding cages so that the test cans could be rotated while being processed. A variable speed drive was used which permitted a range of 4 to 50 r.p.m. By means of thermocouples and compensated rotary contacts, the temperatures of the can contents were measured during both still and agitating processes.

Table 1

RELATIVE HEATING RATES IN VACUUM PACKED VEGETABLES AGITATED DURING PROCESSING (307 x 400 Cans)

Product	Type Agitation	Reel Speed (r.p.m.)	Sterilizing Values (Fs)	Calculated Process Time at 250° F.
Alaska Peas	End-over-end	41	7.4	8.6 min.
Alaska Peas	Intermittent axial	48	7.4	10.2
Alaska Peas	Still	..	7.4	20.0
Sweet Peas	End-over-end	23	7.4	9.6
Sweet Peas	Continuous axial	23	7.4	9.9
Sweet Peas	Intermittent axial	48	7.4	13.2
Sweet Peas	Still	..	7.4	20.0
Cut Green Beans	End-over-end	23	4.2	5.1
Cut Green Beans	Continuous axial	23	4.2	5.4
Cut Green Beans	Still	..	4.2	18.0
Corn	End-over-end	23	9.8	12.6
Corn	Continuous axial	23	9.8	11.8
Corn	Intermittent axial	48	9.8	14.0
Corn	Still	..	9.8	35.0
Corn*	End-over-end	23	10.1	17.0
Corn*	Still	..	11.0	55.0

* 603 x 406 size cans containing 51 ounces of corn and 5 ounces of brine.

Heat penetration tests were made on vacuum packed peas, cut green beans, diced beets, diced carrots, Silver Cross corn, Golden Cross corn, Country Gentleman corn, lima beans and mixed vegetables. The types of agitation which were found to increase greatly the rate of heating in these products may be described as follows:

1. Continuous end-over-end rotation
2. Continuous axial rotation
3. Intermittent axial rotation

The first two types of rotation may be readily obtained in the batch type of cooker used commercially for evaporated milk by so placing the cans in the revolving reel that they will be agitated either end-over-end or about the long axes of the cans. Intermittent axial rotation is the type imposed on cans by the conventional horizontal continuous pressure cooker. In this type of cooker, the cans are carried along the outside of a revolving drum or reel. During part of each revolution of the reel the cans roll against a guide; during the remainder of the cycle the cans are carried quiescent in the reel.

Numerous tests indicated that end-over-end and continuous axial rotation produce essentially the same rate of heating in any one product. Intermittent axial rotation produces somewhat slower heating rates than are obtained with the other types of agitation. However, all three types of agitation greatly increase the rate of heating over that attained in the conventional still process. Figure 1 graphically presents actual heating curves obtained during agitated processing of vacuum packed corn in 307 x 400 cans. The effect of the different types of agitation on the rate of heating is clearly demonstrated by the curves given in this figure.

Calculated Thermal Processes

Typical data obtained from these tests which show how the increased heating rates induced by agitation affect processing requirements are given in Table 1. The sterilizing values, Column 4, apply only for the particular set of conditions under which these series of tests were made. The process times were calculated by the method of Ball (3). Variations in maturity of product, fill-in-weight, or amount of brine added may affect the sterilizing value of the processes. Therefore, the comparative heating rates shown for the different types of processing are valid only for the particular conditions involved.

Effect of Speed of Rotation

Studies involving end-over-end agitation have indicated that the rate of heat penetration is only slightly influenced by the speed of rotation in the range of 10 to 40 revolutions per minute. Data presented in Table 2 show, quantitatively, the effect of speed of rotation on the rate of heating in three vacuum packed vegetables by the end-over-end agitating method. It will be noted that rate of heating in Silver Cross corn was found to be slower at a reel speed of 54 r.p.m. than at the slower speeds. An entirely satisfactory explanation for this is not yet at hand. In continuous agitating type cookers such as the horizontal continuous pressure cooker, the speed of rotation of the cans as they roll along the lower part of the shell is controlled by the speed of the reel which, in turn, is governed by the length of process required.

Table 2

EFFECT OF SPEED OF ROTATION ON HEATING RATES IN END-OVER-END PROCESSED VACUUM PACKED VEGETABLES

Product	Reel Speed	Sterilizing (Value (F_0)	Calculated Process Time at 250° F.
Alaska Peas	10 r.p.m.	7.4	8.9 min.
Alaska Peas	23	7.4	8.6
Alaska Peas	41	7.4	8.6
Alaska Peas	Still	7.4	20.0
Diced Carrots	10	4.5	6.8
Diced Carrots	23	4.5	6.1
Diced Carrots	Still	4.5	21.0
Silver Cross Corn	8	7.7	11.3
Silver Cross Corn	16	7.7	11.7
Silver Cross Corn	54	7.7	14.4
Silver Cross Corn	Still	7.7	35.0

Table 3

RESULTS FROM INOCULATED PACKS

Product	Type Process	Time	Temp.	Calc. Ster. Value (F_0)	No. Cans Packed	Swelled Cans No.	Swelled Cans %
Peas	Agit. end-over-end	5 min.	250° F.	3.8	23	8	35
Peas	Agit. end-over-end	7	250	5.8	22	5	23
Peas	Agit. end-over-end	9	250	7.8	21	0	0
Peas	Agit. end-over-end	11	250	9.8	21	0	0
Peas	Agit. end-over-end	13	250	11.8	21	0	0
Peas	Agit. int. axial	8	250	5.2	48	17	35
Peas	Agit. int. axial	10	250	7.2	48	6	13
Peas	Agit. int. axial	12	250	9.2	48	0	0
Peas	Agit. int. axial	14	250	11.2	48	0	0
Peas	Agit. int. axial	16	250	13.2	48	0	0
Peas	Still	25	240	3.2	48	48	100
Peas	Still	30	240	4.4	48	48	100
Peas	Still	35	240	5.8	24	14	58
Peas	Still	40	240	7.1	24	14	58
Peas	Still	45	240	8.5	24	0	0
Corn	Agit. end-over-end	10	250	6.0	18	3	17
Corn	Agit. end-over-end	12	250	8.0	18	0	0
Corn	Agit. end-over-end	14	250	10.0	18	0	0
Corn	Agit. end-over-end	16	250	12.0	18	0	0
Corn	Agit. end-over-end	8	260	14.4	18	0	0
Corn	Agit. int. axial	10	250	5.1	48	23	48
Corn	Agit. int. axial	12	250	7.2	48	8	17
Corn	Agit. int. axial	14	250	9.2	24	0	0
Corn	Agit. int. axial	16	250	11.2	24	0	0
Corn	Agit. int. axial	18	250	13.2	24	0	0
Corn	Still	25	250	3.0	24	24	100
Corn	Still	30	250	5.0	24	14	58
Corn	Still	35	250	7.7	24	2	8
Corn	Still	40	250	10.9	24	0	0
Corn	Still	45	250	14.2	24	0	0
Corn*	Agit. end-over-end	11	250	4.0	24	9	38
Corn*	Agit. end-over-end	13	250	6.0	24	3	13
Corn*	Agit. end-over-end	15	250	7.9	24	0	0
Corn*	Agit. end-over-end	17	250	10.1	24	0	0
Corn*	Agit. end-over-end	19	250	12.1	12	0	0
Corn*	Still	40	250	4.0	20	1	5
Corn*	Still	45	250	6.3	20	0	0
Corn*	Still	50	250	8.5	20	0	0
Corn*	Still	55	250	11.0	20	0	0

* 603 x 408 size cans.

Inoculated Packs

As is evident from Table 1, on the basis of the data calculated from heat penetration measurements, a reduction in agitating process time from the conventional process time of from 50 to 70 percent was indicated. However, rather than to rely entirely on heating data, a carefully controlled series of inoculated packs of two of the products was prepared to provide an additional check on the accuracy of the heat penetration technique.

Data obtained in inoculated packs of peas and corn and presented in Table 3, show that for a given calculated sterilizing (F_0) value, the agitating processes are equal to or greater than the still process with respect to their lethal effect. The test organism used in the inoculated pack studies was the putrefactive anaerobe designated by the National Canners Association as No. 3679. One milliliter of a spore suspension containing from 200,000 to 250,000 spores was used in each test can. Thermal death time tests had indicated that 5.5 minutes at 250° F. (F_0) was required to destroy this particular strain in neutral phosphate solution. Data shown in Table 3 indicate a greater heat resistance in peas and corn than in the neutral phosphate solution, which conforms with previous observations on this organism.

The inoculated packs were given an end-over-end agitated process in an experimental batch-type retort; a sixty turn horizontal continuous pressure cooker was used for those packs which received the intermittent axial rotation during processing. The can size used for the end-over-end agitated packs was 307 x 400 while for the intermittent axial rotation packs, 307 x 409 cans were employed. Since cold cans having a high vacuum could not be valved directly into a 15 pounds per square inch (gauge pressure) steam atmosphere without danger of paneling, the cans were preheated for ten minutes in boiling water to dissipate the vacuum within the cans.

The results of inoculated packs show that the heat penetration measurements were reliable as a basis for calculating agitated can processes.

Commercial Applications

As a result of the experimental work previously described, during 1946 several canners utilized the agitating process for vacuum packed corn. Experience thus gained may be summarized as follows:

Equipment

It appears from actual tests that horizontal continuous pressure cookers will be well adapted to the agitated can process for vacuum packed vegetables. With this type of cooker, however, there must be some provision for preheating the sealed cans just prior to being valved into the high pressure steam atmosphere in order to avoid paneling difficulties.

Batchwise pressure cookers which provide agitation by means of a revolving crate have, on a commercial scale, successfully produced vacuum packed corn of superior quality. During the past season, this type of cooker was used both for the 12 ounce can size and for the 603 x 408 can size. Since a period of about 5 minutes is generally required to bring a batchwise type retort up to processing temperature, the vacuum in the can is dissipated effectively before the processing pressure is attained; consequently, there is no serious paneling hazard during the come-up period.

Quality Observations

As previously indicated, white varieties of corn, Country Gentleman and Silver Cross, have never been successfully vacuum packed because of the excessive darkening of the corn during processing in the conventional manner. However, these varieties, when vacuum packed and processed with agitation, have a pleasing, bright appearance. Yellow varieties of sweet corn which have been similarly prepared possess a brighter and more natural color than corn which has re-

ceived a conventional process of equivalent sterilizing value.

Most vacuum packed vegetables are canned in 307x306 or 307x400 cans but corn is also vacuum packed in 603x408 cans. As the can size and, naturally, the length of the conventional process increase, the outer portions of the corn become darker. Thus, there exists an appreciable color difference within a single can of still processed vacuum packed corn. The corn at the can center has a reasonably good color while the corn at the can walls appears dark and dull. However, a bright color, uniform throughout the can, is obtained when corn is vacuum packed in the large can and is given an agitating process. With a 51 ounce fill of corn, a conventional process of 55 minutes at 250° F. may be required to sterilize the product. Approximately the same degree of sterility is calculated to result from 17 minutes at 250° F. when the can is agitated during processing.

Development work carried out during the past two seasons has indicated other possible applications of agitating processes. Vacuum packed beets and, to a lesser extent, carrots were also considered to have benefited with respect to color by the agitated process. Some observers have also been impressed with the quality of vacuum pack cut green beans given an agitated process. Whereas the seeds of still processed beans had browned, the seeds of the agitated processed beans remained green. While improved color is the outstanding advantage gained in this process, a flavor improvement has also been observed by experienced tasters. The ideal canned product having garden fresh quality has been brought nearer to achievement by means of this procedure.

In addition to the obvious improvement in the quality of agitated processed vacuum packed vegetables, there are definite indications that heat labile thiamine is retained to a higher degree. Details of the nutritive aspects of the agitated can process will be the subject of another paper.

Future Work

Work is being continued to study various types of agitation as well as to investigate further the nutritional phase. It is recognized that the types of agitation which are reported here do not encompass all possible types. Any type of agitation that increases the rate of heat penetration in the product sufficiently to permit a substantial reduction in the time required to produce commercial sterility may effect an improvement in quality.

The quality improvement afforded by the agitated can process is, of course, most pronounced when fancy raw stock is used. Careful selection and handling of the food is, therefore, necessary to obtain the maximum benefit from the agitated can process. This factor is to receive further study.

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